ECLECTIC READINGS

HALF HOURS WITH THE LOWER ANIMALS

NEW YORK · CINCINNATI · CHICAGO
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HALF HOURS WITH

THE LOWER ANIMALS

PROTOZOANS, SPONGES, CORALS, SHELLS
INSECTS, AND CRUSTACEANS

BY

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"LIFE OF LOUIS AGASSIZ," ETC.

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W. P. 2

PREFACE

At the present day education is not complete without definite courses of nature study. We are living in an age of strenuous business life and activity, where the best equipped students along the various lines secure the best positions. Time was when zoölogy, botany, and kindred nature studies were classed with music and the so-called dead languages, and were taken up as incidentals or were employed in "mind training"; but to-day there are a thousand branches of trade and commerce which require knowledge that can be obtained only through nature study.

It is not necessary that the student, unless he intends to be a teacher of science or a professional naturalist, should be able to pass examinations in the abstruse classification of animals or delve into difficult anatomical studies. What the average student needs is a broad and general idea of animal life, its great divisions, and notably the relationship of the lower animals to man in an economic sense, the geographical distribution of animals, etc. It is vastly more important for the coming lumber merchant to know the relationship which forests bear to the water supply, and to have a general idea of forestry and the trees which make forests, than to be able to recite a long formula of classification or analysis, of value only to the advanced student or specialist. The future merchant who is to deal in alpaca, leather, dye, skins, hair, bone products, shell, pearl, lac, animal food products, ivory, whalebone, guano, feathers, and countless other articles derived from animals is but poorly equipped for the strug-

gle for business supremacy if he is not prepared by nature study, nature readings, and other practical instruction along these lines.

It is believed to-day by those who have given the subject the closest attention that the initial move of the teacher should be to call the attention of the child to the beauties of nature, the works of the Infinite, and thus early inculcate a habit of observation. The toys of the kindergarten should be fruits, flowers, shrubs, trees, pebbles, and vistas of mountains, hills, lakes, and streams, and nature study in some form should be continuous in school life.

In the following readings the story of lower animal life has been presented on broad lines, divested of technicality, and at almost every step supplemented by forceful and explanatory illustrations as ocular aids to the reader. The subject has been divested of dry detail, and I have introduced notes and incidents, the results of personal observation and investigation in various lands and seas, and have given attention to the often neglected fauna of the Pacific coast as well as that of other regions.

While the volume is a supplementary reader, the matter is so arranged that it can be used by the teacher as a text-book, and the pupil who undertakes the various "half-hour readings" of this series will have covered in the main the ground of the ordinary text-book for intermediate grades in the form of readings. In a word, I have endeavored to make this volume a popular combined review and supplemental reader on the lower forms of animal life from the Amœba to the insects inclusive, and the series to follow will present the entire subject of animal life or zoölogy, voluminously illustrated, on a similar plan.

CHARLES F. HOLDER.

PASADENA, CALIFORNIA.

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HALF HOURS WITH
THE LOWER ANIMALS

PROTOZOANS, SPONGES, CORALS, SHELLS, INSECTS, AND CRUSTACEANS

I. INHABITANTS OF A DROP OF WATER

THE most unobserving stroller through the forest or by the seashore can not fail to be impressed by the abundance and variety of animal life; yet the forms visible to the naked eye really constitute but a fraction of the vast horde which makes up what we call life.

In the year 1901 a strange phenomenon appeared off the coast of southern California. The ocean assumed a reddish muddy hue which was traced for four hundred miles up the coast and from one to twenty miles offshore; hence, at a conservative estimate, the reddish color occupied a space of ten thousand square miles. At night it assumed a greenish light, and when the wind rose and formed whitecaps, each became a blaze of light, and the ocean as far as the eye could reach was converted into a mass of seeming flame. The sands of the beach gave out flashes of light when touched; the footsteps of dog or man on the sands left an imprint of vivid light, and figures made on the sands with a finger or stick stood out in lines of light. Ten thousand square miles of phospho-

rescent light; ten thousand square miles of living beings, each so minute that it was almost if not quite invisible to the human eye. Who could estimate the individuals in one square mile, one square foot, or even a drop of this reddish water? This illustrates the fact that the greater number of the earth's population are unseen, even though not invisible to the unaided eye.

These minute animals are as interesting as the larger forms. Equipped with a microscope, we are prepared to explore the regions in which they live and observe their habits. A favorite hunting ground for this small game is some long-standing water in which plants have been growing. Placing some of this, with the green scraping of the glass, on the slide, we shall soon make out, moving mysteriously along, something which resembles the white of an egg, an atom of slime or jelly. Now it stops and throws out parts of itself which seem to fuse together again; now it is long, now short and compact, again circular. You almost believe it is a mere atom of slime, yet it is an animal which eats and lives its life cycle in a drop of water, one of the lowest of all animals.

It is called Amœba (Fig. 1), and although it is hardly a hundredth of an inch in diameter, yet if we devote some time to it we shall find that it is a very remarkable animal. Thus if it wishes to move in any given direction, a portion of the body becomes a seeming leg and protrudes in that direction, the rest of the body following, drawn along in some mysterious manner. If it wishes to eat, it is not obliged to twist around to bring the food or victims opposite the mouth, as a mouth forms there and then; the Amœba merely glides around it and covers it up.

We may even notice a difference in the parts. Thus the center calls to mind ground glass; it is blurred or granular, while around the edges is a little border which is transparent, like ordinary window glass. So the Amœba is a minute mass of jelly inclosed in a layer a little clearer.

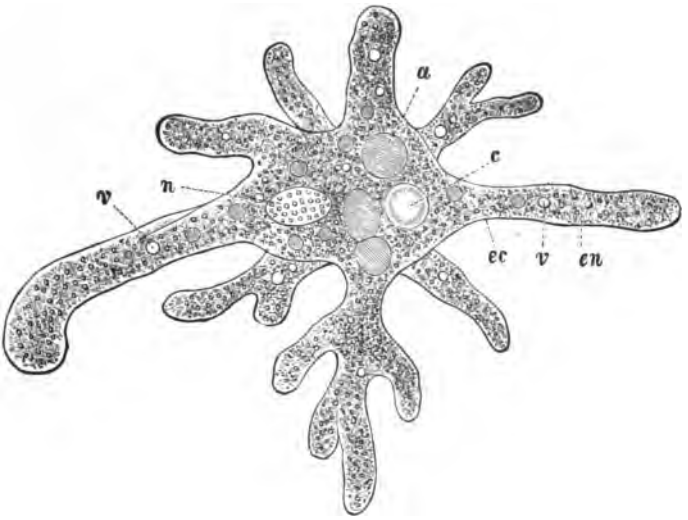


FIG. 1.— *Amœba proteus*, with the pseudopodia (false feet) protruded, enlarged 200 diameters (after Leidy): *n*, nucleus; *c*, contractile vesicle; *v*, one of the larger food-vacuoles; *en*, the granular endosarc; *ec*, the transparent ectosarc; *a*, cell of an Alga taken in as food (other cells of the same Alga are obliquely shaded).

Floating in the granular portion is seen a minute round body called the nucleus, clearer than the fluid in which it rests, and not far away another clear, circular body, which from time to time contracts or sometimes disappears in a marvelous fashion, but always returns. This is called the contracting vesicle, and here our discoveries end, so far as organs and structure are concerned, as these are nearly

all that have been found; yet the Amœba eats, doubtless sleeps, and grows.

We may watch it at its dinner. When a victim is found, an animal smaller than itself, out shoots a little cape or extension from the clear rim, creeping slowly up the side of the animal; and if we watch very closely, we shall see the thicker portion of the Amœba, that which calls to mind ground glass, running or flowing into it. Then another false foot, as it is called, slowly creeps out on the opposite side and joins its companion, more of the ground-glass matter slides or pours into this, filling it out, and, presto! the two arms merge one into the other. The victim has been swallowed and is now being digested (Fig. 2, *d*).

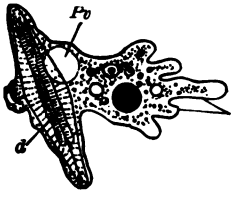


FIG. 2. — Amœba eating: *Pv*, contracting vesicle.

That this minute atom has its likes and dislikes is evident, for if the food is too large, or not to its taste, it retracts, or even draws away from it after it has swallowed it. The shells of its victim, if it has them, are rejected in a manner equally simple; the Amœba flows away from them. Jar it with a needle point and it contracts, showing that it can be irritated. At times the body is seen to divide and two Amœbæ are formed (Fig. 3), each of which has a separate existence from then on. Such is one of the lowest of all animals. It is made up of but a single cell. All the members of the other great branches of the animal kingdom and the higher

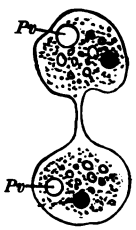


FIG. 3. — Amœba separating.

plants are made up of many cells; hence we see that the Amœba is the simplest and lowest of all animals.

In looking into our drop of water our attention has perhaps been distracted by other animals. In point of fact, it is very difficult to keep the eye on this mass of slime in its slow movements, for about it, over it, and constantly

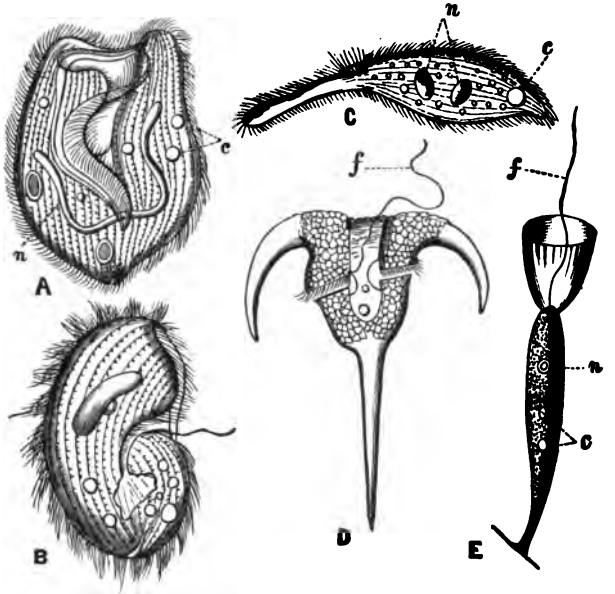


FIG. 4.— *Ciliated Infusoria: A*, Bursaria; *B*, Nyctotherus; *C*, Amphileptus; *D*, Ceratium; *E*, Monosiga; *f*, flagellum; *n*, nucleus; *c*, contractile vesicle.

bumping into it are countless other forms whose motions convey the impression that life to them is very active. The most numerous are little objects (Fig. 4) resembling hats or bells, which go rushing along, bumping aimlessly into all others, and always in a hurry. Around the edge of the bell or hat are numerous hairs (cilia) which are

really locomotive organs by which the little animals whirl themselves along. Near them we see numbers of similar objects, each one forming the cup of a seeming flower, each having a long stem. These are Bell Animalcules (Fig. 5) or Vorticellæ, among the most beautiful and graceful of all the minute animals, but much higher in the scale of life, as they have a permanent mouth and form.

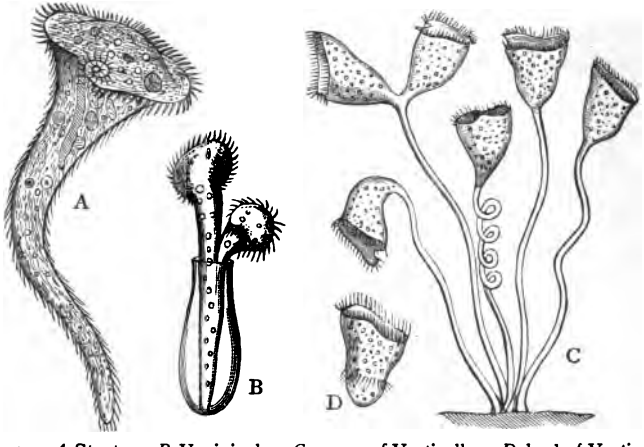


FIG. 5. — *A*, Stentor; *B*, Vaginicola; *C*, group of Vorticellæ; *D*, bud of Vorticella.

Among them, swimming rapidly, comes a giant by contrast, the Paramœcium (Fig. 6) or Slipper Animalcule, so called from its resemblance to a slipper. It, too, is a higher form than Amœba, as it has a permanent shape; yet in other ways it is as simple as Amœba. The Paramœcium has a marvelous array of oars which cover its body. Under the glass they look like eyelashes or whips, and by their rapid movements they drive the animal along. On the side is the mouth opening, into which the animal fans minute animals, and they can be seen swept along

by the irresistible current, caught by the mouth if desirable, or tossed off if not to the taste of the wonderful living slipper. After glancing at the drop of water for a few moments the observer is convinced that here is a world in itself, with a population growing, increasing, developing, devouring its prey, and in such multitudes that the mind can not grasp the figures.

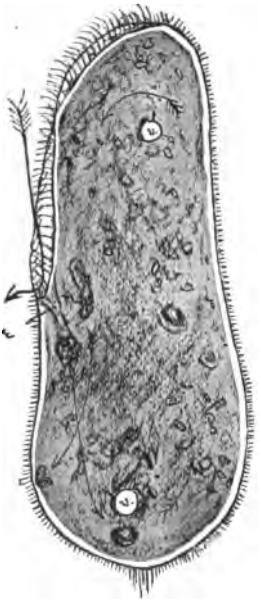


FIG. 6. — Paramœcium: *e*, mouth; *v*, contracting vacuoles.

If the reader visits Egypt and climbs the pyramids, he will be impressed by these the greatest works of mankind. If a small portion of the stone from which they are constructed is placed under the glass, it will be found in many instances made up almost entirely of beautiful shells (Fig. 7). These are the shells of an amœba-like animal known as a Nummulite, which lived millions of years ago, and whose fossil remains formed the stone from which the early Egyptians in turn built the great piles or monuments of their kings. Man is powerful, but in this instance one of the most insignificant of animals made his work possible. These shells are of great beauty

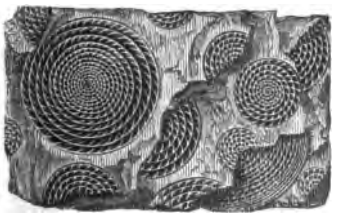


FIG. 7. — Nummulites.

and variety (Fig. 8). Many are perforated, and through the minute holes are seen the false feet of the Amœba reaching out for food. They illustrate the boundless resources of nature, and suggest that the very lowest of creatures are not too insignificant to be dressed in most beautiful garbs, as all these forms vie with one another in the delicacy of their designs (Fig. 9) and the grace of their shapes. Some of these shelled forms are giants two inches across. All these minute shells perform a marvelous work in building up the crust of the earth, forming the bottom of deep

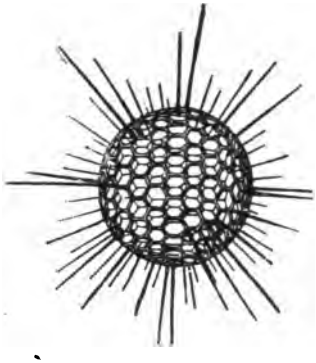


FIG. 8. — Flint-shelled Radiolarian.

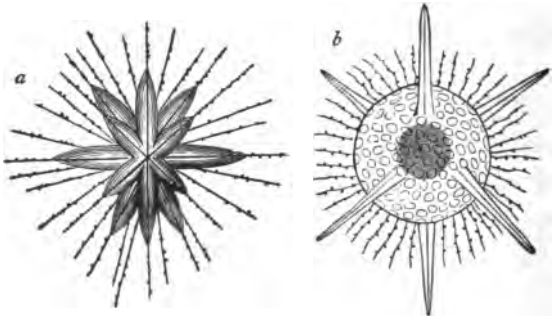


FIG. 9. — Flint-shelled Polycystina.

seas and the platforms of coral reefs. The chalk cliffs of England are composed of shells of unestimated millions (Fig. 10), which were once dropped upon the bottom of a deep sea and piled upward until some were crushed into

a shapeless mass of lime, others retained their shapes (Fig. 11); and all, by some convulsion, were afterward lifted high into the air.

The entire ocean is as thickly populated with these atoms as the drop of fresh water. The shelled forms are as constantly dying, the shells falling or sinking in a continual rain of shells upon the bottom, piling up eternally.

FIG. 10. — Foraminifera from Atlantic ooze.

FIG. 11. — Section of English chalk cliff. Highly magnified. Bottom of an ancient sea.

Who shall estimate their countless numbers? It is believed that these minute shells are as abundant down to a depth of six hundred feet as they are at the surface. There are more than sixteen tons of limy shells floating in the uppermost one hundred fathoms of every square mile of the ocean. These facts convey an idea of one way in which the earth is growing — increasing in size but not in weight, as these delicate creatures merely secrete the carbonate of lime which forms their shells. They take it from the surrounding water of which it has been a part.

It would be of great interest to learn exactly how these humble creatures take lime from the water and produce

shells of such marvelous beauty: to learn why one is of lime and others, like the Radiolarians, are of silica; why some live at the surface and are free swimmers, while others creep about in the ooze. When the deep-sea explorers first began to dredge, they found over vast areas a peculiar mud or ooze, and investigation showed that it was formed almost entirely of the shells of a certain minute shell maker, from which it was named the Globigerina ooze. Finding these vast banks or beds of mud at this depth is suggestive that the deepest seas may yet be filled by the dropping of this invisible rain; but as the average depth of the ocean is nearly if not quite three miles, many centuries must pass before this will be accomplished.

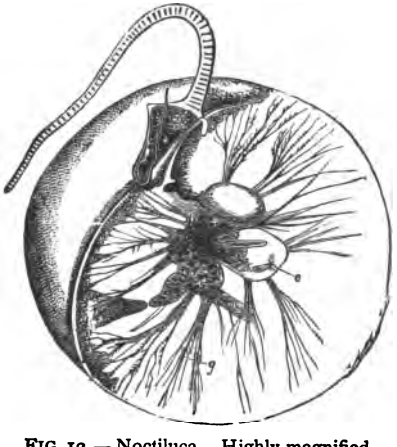


FIG. 12. — Noctiluca. Highly magnified.

The marvelous phosphorescent light previously described came from a minute armored form known as Peridinium, but even this is exceeded by the glories of a little monad called Noctiluca (Fig. 12). It is a giant of the tribe, and is visible to the naked eye, being almost as large as the head of a pin, and resembling a currant in shape. It has a single hairlike organ or lash, supposed to be a locomotive organ, by which it whirls itself through the water. Of all the light givers of the sea this is the most common, some of

its species being found in every sea, and where they are, it is necessary only to splash the water to cause a blaze of light to follow. A French naturalist placed on record the fact that so brilliant was the light occasioned by this minute organism in African waters that he read by their light standing on a beach where a heavy surf came pounding in upon the sand. The light of this little creature is remarkable not only for its vividness but for its many different tints. Now it is a fitful vivid green, again the water is a blaze of yellow light, or orange. At such times, when a ship is plowing along, the light is so brilliant that the sails and rigging are brilliantly illumined, casting weird shadows.

Some Noctilucæ emit a clear blue light, but when the same animal is disturbed it appears white with green and blue flashes of great beauty and intensity — a telling illustration of the boundless, and marvelous, resources of nature. Many interesting experiments have been tried with these dainty light givers. A tube fifteen millimeters in diameter was filled with them, and by shaking this novel lamp a printed page was read a foot distant; yet when a delicate thermometer was thrust into the fiery mass, the mercury was not affected in the slightest, showing that here was that wonder of wonders — vivid light without heat — a secret which man has vainly endeavored to wrest from nature. The vast number of these minute creatures can be realized when it is said that the ship *Magenta* sailed nearly five hundred miles among swarms of Noctilucæ, which gave splendid displays of phosphorescent light at night. Sometimes the light emitted was milky white; again it was green, or blue, the different species possessing different colors.

II. THE SPONGES

ALMOST every day, for several years, I devoted one or more hours to the pastime of floating or drifting over a part of the great coral reef which constitutes the most westward portion of Florida where it reaches out in the direction of Yucatan. The islands composing the group are the Tortugas Keys, and are just above water; indeed some disappeared when a particularly heavy hurricane came, and in the center of the island upon which I lived, the water at very high tide appeared above the surface.

Among the commonest objects seen on the reef were huge vases (Fig. 13).

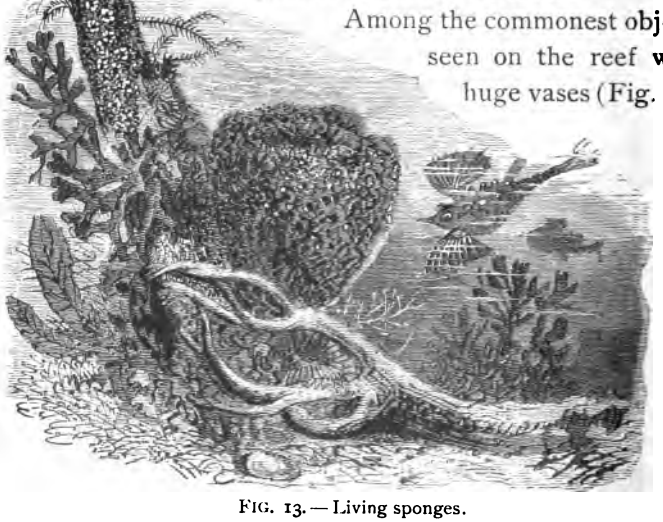


FIG. 13. — Living sponges.

They were found in water from a foot to fifteen feet or more in depth, and were attached so strongly to the bottom that it required considerable strength to lift them up. Some were three feet high, and I have often dived down to them and for a few seconds sat upon them as a jest for the edification of my companions in the boat above. A common name for them on the reef was "Neptune's Seats." The seats were sponges, and their collection on the Florida reef has for many years constituted an important industry, vessels being fitted out from Key West and other places for this purpose. This industry is also followed in the Mediterranean Sea, where the finest sponges known are found. To take them, men go out in small boats, and in shallow water bring them up with hooks. In the greater depths a water box is used, a box with a glass bottom, which placed over the water makes everything visible, and by this the sponger secures the sponge. Other collectors, especially those of Syria, dive for them and wrench them from the bottom, then ascend to the surface with the load. There are many different kinds of sponges, those commonly used being divided into grades, from the delicate face sponge to the coarse specimens used for washing carriages. Then there are hundreds of kinds of sponges which have no value but to form veritable mimic forest growths at the bottom of the sea (Fig. 14). Some grow upon stones or sea mud and are brilliantly colored; others again are like glass, and all represent one of the lowest forms of animal life, yet one of the most beautiful, and one that is very useful.

In handling a sponge the most indifferent person has

not failed to observe two peculiarities, one that the sponge is soft, another that it is filled with holes, small

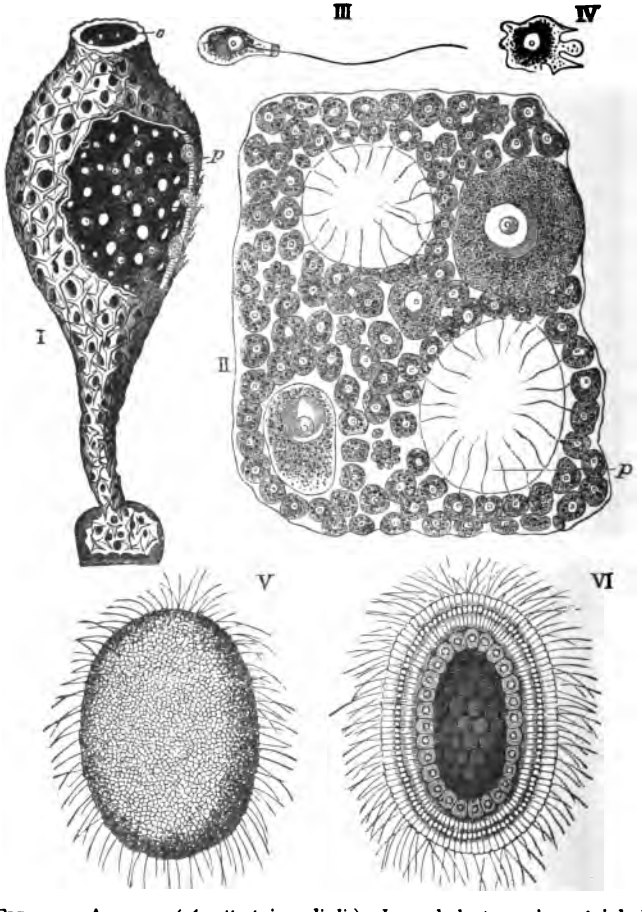


FIG. 14. — A sponge (*Ascetta primordialis*): I. *o*, exhalent opening; *p*, inhalent pores; *g*, ova. Starlike spicules are seen on the outside. II. Section showing pores (*p*), with cilia of the cells extending into them. III. Cell showing lash, or cilium. IV. Same, with lash retracted. V. Embryo of *Ascetta mirabilis*. VI. Section of embryo.

and large, and has a marvelous faculty of retaining water, in which property lies its value to man. Now if we take a sponge and cut down through it, making a section, we shall find that these holes are nothing more or less than doors or mouths which lead into the interior of the sponge. If we are so fortunate as to have a live sponge to study, we shall see that water is being forced through all the small pores and out into the larger ones; and if we could examine the water, we should see that the water which passed in, is laden with living creatures which have been described in a previous chapter, while the water which is discharged contains little or no living matter. The reader will have suspected what this in-going and out-coming is. It is the operation of eating on the part of the sponge, which, while it looks very much like a plant and appears to be growing from the ground, is an animal, or a community of many cells — a many-celled animal.

In our section of a sponge we may follow the winding channels which connect one part of the sponge with the other, and we see that the body is a mass of fibers made up of curious and beautifully shaped objects called spicules (Fig. 15). The spicules are the bones of sponges, the hard

FIG. 15. — Flint spicules highly magnified.

portion, the framework. In the sponge we find here and there little oval rooms, and in these are packed, side by side, minute objects with tails (Fig. 16). Each little cell has its tail upon the outside, which is really a whip or lash, used for capturing passing food. In these rooms the cells congregate and are fed by the constant onward flow of water laden with food. The food is in the shape of minute animals and plants which these little whips catch as they pass by. The whips have another purpose; their constant motion serves to force the water along through the canals, carrying air as well as food.

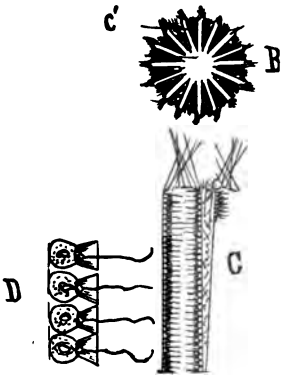


FIG. 16. — Parts of a sponge (*Grantia*): *B*, cross section showing pores leading into tubes *C'*; *C*, enlarged tube; *D*, cells magnified.

Some of the sponges have very singular shapes. One is called the finger sponge, and often takes the form of a hand. Others are very long and slender (Fig. 17). Some are perfectly round; others creep over stones and form a brilliant red matting, a charming object in the water.

The great vase or seat sponges are often the habitations of animals of various kinds — shrimps, crabs, and fishes. After a hurricane I have found a windrow of them on the beaches. When the sponge is taken from the water it is fleshy and seems covered with a reddish colored mass of jelly, or it is black, brown, or yellow, as the case may be. The sponge of commerce is the skeleton, the mass of living

spicules after all the animal matter has been removed and the framework, elastic and soft, thoroughly bleached.

The variety in shape, color, and size in sponges is remarkable and can not be appreciated until a collection of these lowly animals is seen with the individuals side by side. In such a collection one sponge, shown in Figure 18, will attract the observer for its remarkable beauty; indeed few would consider it anything but a beautiful glass vase. Some years ago one was brought to England from the South Pacific and sold for several hundred dollars. It was believed to be the work of some skilled native artist in glass. But finally some one discovered that the natives did not make them, but hooked them up from the bottom of the ocean, when they had no resemblance to the glass vases of commerce sold for enormous sums under the title of Venus's flower basket. When first brought up the vase was dark and covered with mud; then it was found that it was a sponge,

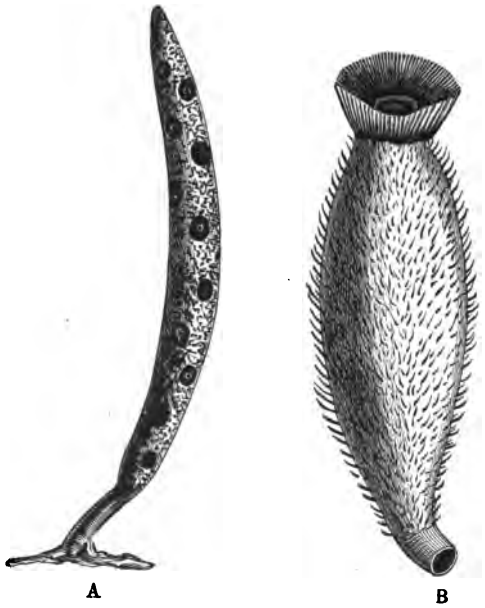


FIG. 17.—Sponges: *A*, Axinella; *B*, Sycandra.

FIG. 18. — Skeleton of a sponge.

and that the so-called glass was merely the interior, the framework over which was drawn the ugly exterior animal matter. It is needless to say that the enormous price of the Venus's flower basket dropped, and it can now be bought for a few cents.

No more beautiful object can be imagined than this sponge, known as the Euplectella. It has great wisps of glasslike matter at the bottom, which anchor it in the sand or mud, and the framework appears to rise upward in whirls, the surface being made up of squares or basket work, so artificial that it is

difficult to believe that it is not of human make. This vase has a top to it. It is perforated with squares, and is often a prison for various small animals, as crabs, which have passed into the interior when very small and which are now too large to escape, only their claws or feelers being seen protruding through the little portholes.

The sponges in their habits show a variety of tastes. Many grow in the mud, the majority upon rocks. On the New England shores there is one of a yellowish hue which lives in the sand. It is very light, and the pores are so fine that the sand does not enter them. After a storm on Cape Cod thousands are found on the beaches, blown far inshore. Black and pure white sponges are found in fresh water as well as in salt. They increase by depositing eggs. In one stage of their development the young (Fig. 14, V.) are free-swimming animals.

III. THE JELLYFISHES

Among the most beautiful and fragile of all animals are the singular forms which we call jellyfishes (Fig. 19).

Fig. 19. — A jellyfish (*Pelagia*).

They are so delicate that we can not lift them, and in many instances they have ninety-five per cent of water in their composition. They would almost seem to be purely ornamental did we not know that they fill an important niche in the hall of nature, constituting almost the sole food of many whales.

The jellyfishes are found in all waters, salt and even fresh. They may be seen floating near or at the surface, often in vast numbers. Sometimes they are found deep in the heart of the upper part of the ocean, often in such quantities that the water appears to be filled with their graceful shapes.

In the Santa Catalina Channel a beautiful lavender-hued form is common, the water being alive with them at times, and I have seen specimens with tentacles streaming behind them an estimated length of twenty feet, the entire animal appearing like a huge comet in the blue sky of the ocean. Mrs. Agassiz describes a jellyfish called Cyanea which was six feet across its disk and which had tentacles over one hundred feet in length. Specimens have been seen in East Indian waters which were much larger, having an estimated weight of several tons. An English naturalist describes one which stranded in India and gave out so vivid a light at night that the natives were afraid to approach it; yet large as was this monster, a few hours in the sun caused it to disappear or literally evaporate, water forming so large a part of its make-up.

In appearance the jellies resemble umbrellas, dinner plates, or inverted bowls, from which depend streamers or tentacles of various kinds and shapes, often richly colored, especially the very minute forms. The mouth is in the

center, the eyes are around the edge of the disk, while the huge tentacles, which can be lifted or lowered as fancy dictates, are so many fishing lines by which this jelly finds its food. I have often watched them floating near the surface, the delicate vermilion-tinted tentacles floating gracefully about, and serving as so many tempting baits. Should a sardine or other small fish venture to attack this tempting lure, we can almost imagine it struck by an electric

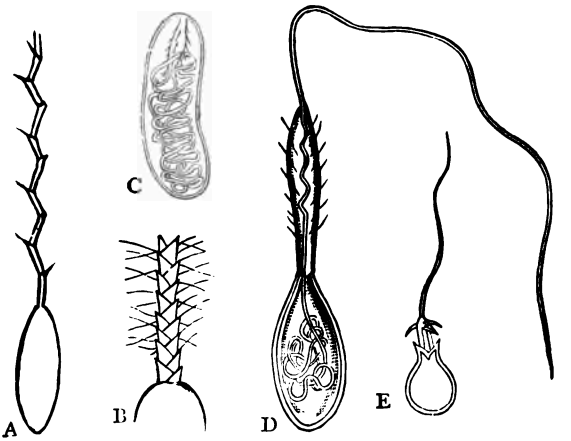


FIG. 20. — Lassos or weapons of a jellyfish.

shock, as it rolls over dead. The secret is very easily discovered. Lift the tentacles with the hand and a burning sensation will be experienced, in some cases very painful. The tentacles of the jellyfish are armed with stings.

The weapons are known as lassos (Fig. 20). Under the microscope the tentacles appear to be filled with little cells or oblong objects, which when examined are found to be capsules (*C*) resembling long glasslike bodies in which is

coiled a thread. This latter is a miniature javelin, and when the tentacle of a jellyfish is seized by a fish or an enemy, tens of thousands of these cells literally explode (*D*) and the javelin springs out like a Jack-in-the-box (*A*) and penetrates the intruder. With many jellyfishes the effect of this bombardment is a stinging sensation. It paralyzes small fishes which, when benumbed, are lifted up by the tentacles and eaten.

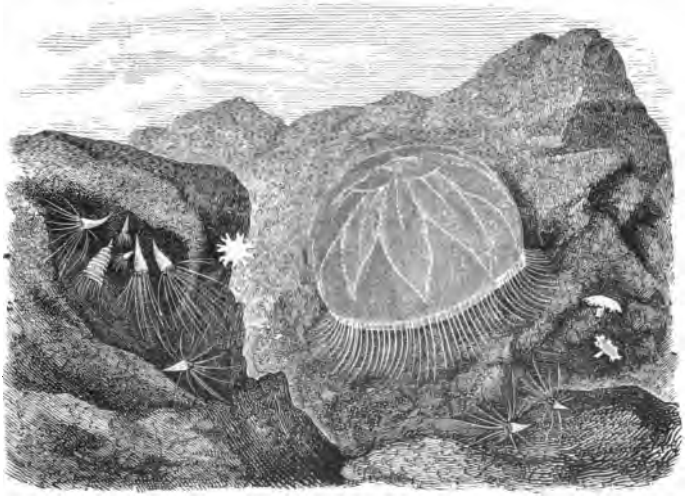


FIG. 21. — Jellyfish and young (*Aurelia*).

The jellies develop in various ways. In Figure 21 we see a common and very beautiful form resting on the rocks. Near by are various little plantlike creatures, the young jellies, which undergo a remarkable series of changes in their growth from the egg to the adult form. Minute eggs are deposited in the autumn, which drop into

the crevices of the rocks and soon change to pear-shaped objects which attach themselves to the bottom. Each little jelly pear (Fig. 22) divides after a while until it looks like

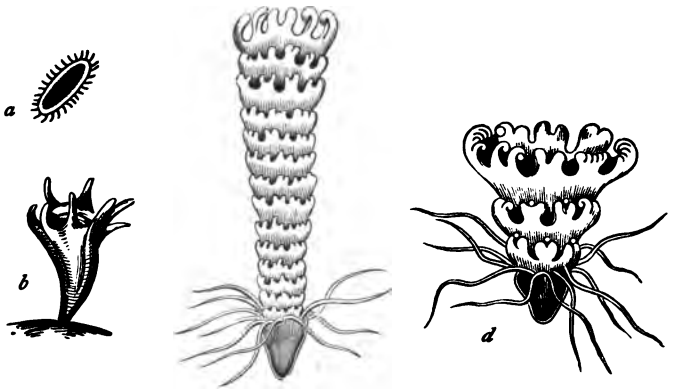


FIG. 22. — The development of a jellyfish.

a pile of platters one upon the other. The upper one dies, and the rest break away, each becoming a separate jellyfish, which ultimately grows to be a giant.

The story of the growth and development of these little jellies is one of the most marvelous pages in the history of nature. In some forms the father and son are entirely different, and it is only the father and grandson that resemble each other. Not only this, the father is a seeming plant, while the son is a free-swimming jellyfish of great beauty. The seeming plant is in reality a hydroid community. The buds are immature jellyfishes which finally break away and assume the typical jellylike form, free swimmers bearing not the slightest resemblance to the parent. This jelly deposits eggs which attach themselves to the bottom and become not jellies but the

shrublike form. Hence it is the parent and its grandchildren that bear a close resemblance to one another.

No conception of the beauties of the jellyfish can be formed from pictures, or from the stranded "sunfishes" found along the shore at low tide. In the water they move along or swim by the slow pumping or rising and falling of the umbrella or disk, and are of all the colors of the rainbow. Some, like the dark, lavender-splashed specimens, can be seen from a long distance, while others are almost invisible, in fact, are like glass or crystal, and interpose no obstacle to other forms beyond. The ocean is filled with them; their chaste shapes presenting one of the most beautiful spectacles to be observed in the ocean as they drift about.

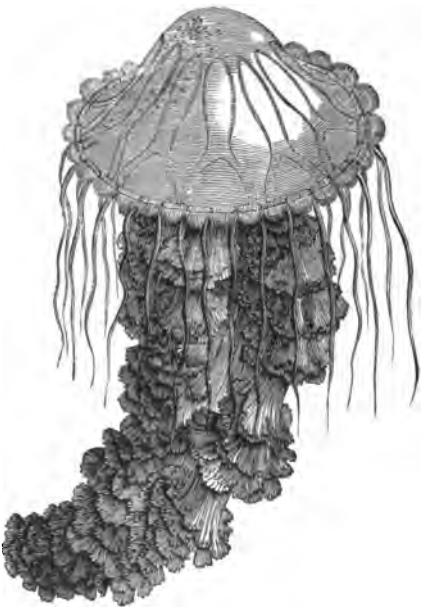


FIG. 23. — A large jellyfish (*Cyanea*).

Some are merely great disks towing behind them enormous masses of pink fluted jelly, as in Figure 23; others are simple flowerlike forms (Fig. 24).

FIG. 24. — Flowerlike jellyfish (*Lucernaria*).

If these graceful forms are beautiful during the day, what shall we say of them at night, when they blaze and glow with marvelous phosphorescent lights of yellow, green, and gold. Gazing into the ocean these great jellies appear like comets moving through the clear atmosphere of the sea. The Cyanea is pale blue. One jelly, called Melicerta, emits a pale golden radiance, and Rhizostoma (Fig. 25) gives out a fixed steely blue light. It would be difficult to find one out of all this marvelous procession of living gems that does not emit a light more or less peculiarly its own.

FIG. 25.—Jellyfish (*Rhizostoma*).

If this phosphorescence is fascinating as we are drifting over the scene and the light givers are not alarmed, how much more dazzling is the display when the sea is beaten into foam. In a certain cave on the coast of Santa Catalina Island, California, the sea rushes in and, striking the rocks, rises like a wave of fire and bathes the entire interior with liquid light which slowly falls in gleaming rivulets to the sea.

But the most magnificent display is seen at Point Firmin Light during a storm. Here stands a lofty rock pillar which has breasted the sea for ages. At low tide, when a storm sea strikes the ledge, the spray rises to an altitude of three hundred feet, and spreading as it rises, fairly fills the air with a gigantic mass of silvery light, that on a dark night presents an appalling spectacle as it

drops, changing its shape continually. On such nights the line of breakers changes into silvery flame, while the roar resembles a cannonade, fairly shaking the earth. In the breakers the jelly light givers are breaking up and adding fuel to the seeming flame. Some, as Pelagia, are luminous over their entire surface; in others, the light is confined to certain parts, which are either fixed or flashing lights. How vivid this light is may be imagined when it is said that a single jellyfish, Aurelia, when squeezed into a glass of milk, has produced a light by which a letter was read.

This peculiar phosphorescence is not their only interesting feature. Nearly all the jellies afford protection to fishes, crabs, and various small animals. As I drifted over the waters of the Gulf of Mexico almost every large jelly that I examined had one or more little fishes of the mackerel family up among its lobes or tentacles. As they always resembled the tentacles in tint or color, a delicate pink, they found protection amid the death-dealing darts. The most remarkable example of this strange companionship of dangerous jellies and delicate fishes is found in the Physalia, or Portuguese man-of-war (Fig. 26), one of the most beautiful of all the animals that make up the group to which the jellyfishes belong. Physalia is a bubble tinted with purple hues, four or five inches long — a fairy ship of pearly tints. On its upper portion is a sail which can be raised and lowered, while from the lower part depends a mass of beautiful blue or purple tentacles which sometimes are nearly one hundred feet in length. During the summer of 1902 I found them on the outer islands of the Texan coast in great numbers, stranded on the sands, while

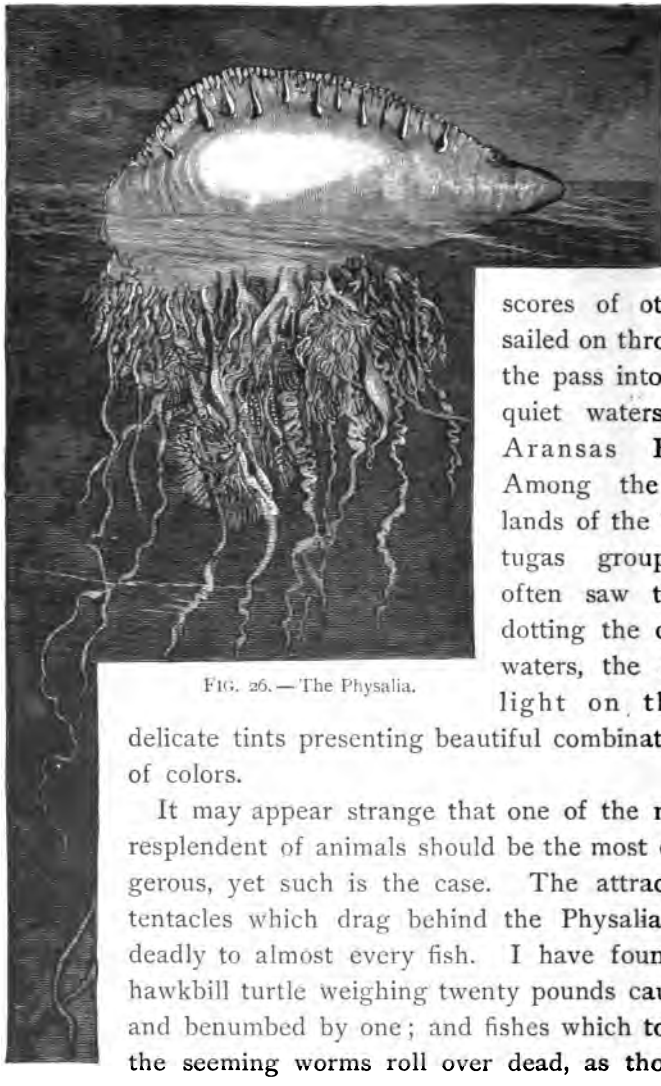


FIG. 26. — The Physalia.

scores of others sailed on through the pass into the quiet waters of Aransas Bay. Among the islands of the Tortugas group I often saw them dotting the calm waters, the sunlight on their delicate tints presenting beautiful combinations of colors.

It may appear strange that one of the most resplendent of animals should be the most dangerous, yet such is the case. The attractive tentacles which drag behind the Physalia are deadly to almost every fish. I have found a hawkbill turtle weighing twenty pounds caught and benumbed by one; and fishes which touch the seeming worms roll over dead, as though stunned by an electric shock. In swimming around one

of the keys of the reef I unwittingly passed over the train of one, and if I had been alone, I doubt if I could have reached the shore, so terrible was the burning pain. A year afterward my flesh had the appearance of having been tattooed in fanciful designs. Yet despite the deadly nature of this maze of traps and lures, a little fish lives up among them, and what is more remarkable, is the exact color of the tentacles, a rich blue. So exact is this resemblance that it is very difficult to see the little attendants, but if you lift the dainty man-of-war by its sail, they rush about greatly alarmed by their exposed condition. I have been told that the Physalia eats these attendant courtiers, but in hundreds of specimens which I examined I never saw the little fish in the toils. They swam about among the death-dealing tentacles with the greatest freedom. The secret of the poison lies in the lasso cells of the tentacles, as in the case of the jellyfish, but in this instance they are much more poisonous. Along the southern beaches, where the Physalia is common, their stranded hulks form after storms a windrow of mimic balloons which explode like torpedoes beneath the feet, as one strolls along the sands.

No branch of the animal kingdom contains more beautiful and radiant forms than that which includes the Portuguese man-of-war. They are the fairy crafts of the sea, graceful, seemingly formed of water in some instances, and nearly all so delicate that they usually drop to pieces when captured. I have kept all for a brief time in confinement, but few survived more than a few hours.

In a tank at Santa Catalina Island I had at one time, besides a Portuguese man-of-war, the delicate Velella, a

raft of sheeny silver which floated on the surface, having a silvery sail (Fig. 27), beneath which hung short tentacles of a brilliant hue. More beautiful than these were the "swimming bells" — strings of beautiful pink and crystal bells attached to a central cord (Fig. 28). One of these, Praya, three or four feet long, was a veritable string of little pumps, each of which pumped water very rapidly, urging the entire animal along. Each little cup seemed carved in glass and colored by some artist, so perfect were the tints, so delicate was the design. Many of these forms could be seen in the ocean only by fitful glances, so delicate were they. Most beautiful of all these prisoners in the tank was one called Physophora, or by the Italian fishermen, Boguetti. It had a central stem like the glass of a thermometer, the bulb being uppermost and filled with a gas that was almost

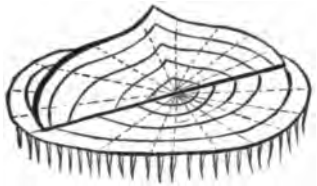


FIG. 27. — Velella.

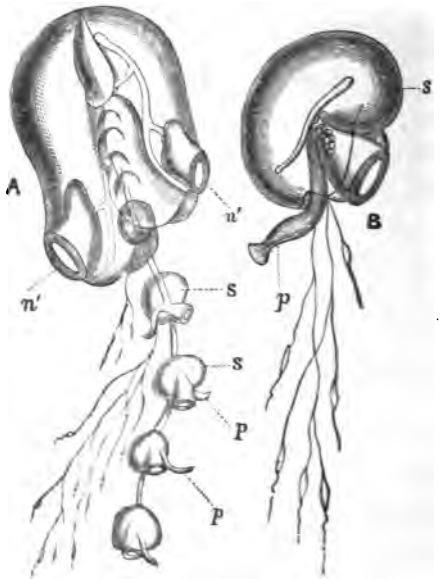


FIG. 28. — *A*, Praya; *n'n'*, mouths; *ss*, swimming bells. *B*, single polypite (*p*), enlarged.

exact in its resemblance to mercury. When the bulb was full the animal floated at the surface. I have watched the animal force the gas down by repeated restrictions of the tube until it could descend beneath the surface with ease. On the sides of the central pillar were numbers of beautifully tinted pumps, the locomotive organs. Underneath was a mass of lacelike tentacles, richly tinted, purple and vermilion, so Physophora was one of the most gorgeous objects to be imagined. A unique feature of this animal was its rapid movements. When it so desired it dashed around the tank with great velocity, in strange contrast to the labored movements of other jellylike forms, or the utter and complete helplessness of Physalia, Velella, or Porpita. These latter were ships at the mercy of every breeze, the Physalia alone being able to anchor itself on a lea shore, but always beaten in by the heavy surf.

IV. THE SEA ANEMONES

In the last century many of the animals of the ocean were considered plants, and the sea anemones, which appear to open and shut like flowers, were described and painted in verse and prose as the flowers in the gardens of the sea. The sea anemone, common in almost every rocky pool, and found everywhere from the rocks bare at low tide to the greater depths, certainly has a very flowerlike appearance, some of them resembling a flower without a stem. Petals branch out on every side. Some are large, some small, and as though to carry out the idea the anemones are of all possible shapes and colors. Some are vivid red, others blue, some almost white, others spotted black and white, brown and barred. Almost every color is seen. Some are tall and slender, five or six inches high; others are flat. Some live in exposed places, as the luminous form attached to the shell of a hermit crab in Figure 29. Others bury themselves in the sand or hide beneath large jellyfishes, displaying the most remarkable tastes and fancies. Little wonder that the ancients believed that they were flowers. But touch one, and presto! it appears to draw within itself, and becomes a mere mound in place of the gorgeous creature which spread its splendors to the current.

The sea anemone is a highly organized animal several degrees above the jellyfishes in the scale of life, yet a very humble creature after all. They are tubular in shape,

and are attached to the rocks by a sucking disk which clings so tightly that it is only with great difficulty they are forced off. Yet they have the power of moving, and slowly, very slowly, drag themselves along. Some move perhaps three or four inches a day; but this would be a

FIG. 29. — Sea anemones — one in the upper right hand corner is a luminous form on a hermit crab.

long journey for many anemones, and the greatest number are fixed for life and live in crevices in the rocks. The only one I ever saw actually moving was traveling slowly across the glass of a tank. As it moved small pieces of the disk appeared to be torn off and left behind, each of which grew into a perfect sea anemone.

On the upper portion around the rim are the tentacles, armed with the same kind of ammunition (Fig. 30) found in the jellyfish, namely, lassos. In the center is the mouth.

FIG. 30.—Lasso or dart of a sea anemone.

We may imagine the anemone feeding, and we may easily see what occurs. The anemone displays its beautiful flowerlike face; it is spread out, waiting for prey. A shrimp comes swimming along, and innocently drops upon the beautiful flower. The moment it touches the attractive arms it is pierced by the lassos, and unless very vigorous is soon involved. The arms are thrown over it, the body shrinks, grows perceptibly smaller, the shrimp is pressed against the mouth, and finally ingulfed, and the once gorgeous anemone resembles (Fig. 31) a mere mound, a form which it may retain until the food is digested.

FIG. 31.—A sea anemone closed.

The structure of this interesting animal may be observed by glancing at Figure 32. The stomach is placed in the center of the animal, and is held in position by a number of partitions that are attached to the side of the anemone. These form little rooms in the body of the anemone, arranged about the stomach, but not opening into it. Each room has two windows leading into the room beyond, hence all are connected, and at the bottom all are connected

with the stomach. Each room connects upward with a tentacle, which is hollow. When the animal is swallowing, the food passes down and is floated in water through the various rooms, the hard portions being rejected at the mouth. The animal has a current of water circulating through it almost continually, and it is water which, filling them, makes the tentacles stand upright and firm. Between the bases of the tentacles are the eyes. When the animal closes up, it forces the water out of its mouth and is able to shrink to a small and inconspicuous object.

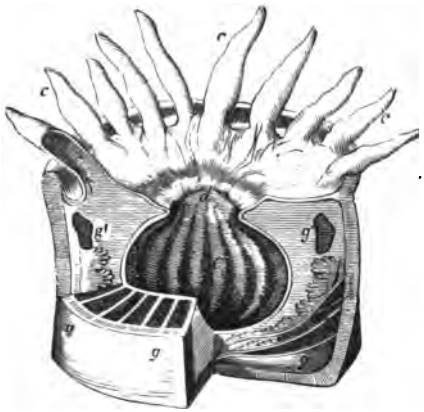


FIG. 32. — Section of an anemone: *c*, tentacles; *g*, little rooms; *d*, mouth; *g'*, opening between rooms; *a*, sucking deck or foot; *e*, stomach.

Lowly as are the sea anemones, they often display an amount of intelligence that few would give them credit for. On the Florida Reef was a large lagoon, its bottom pure sand, and so light that the slightest dark object was easily observed. In the sand, buried several inches deep, lived a large anemone, whose normal hue was a dark brown, but when expanded was almost the exact color of the sand; not only this, its tentacles were covered with bits of sand. In a word, the anemone had disguised itself so that large and threatening fishes would not see it, as they swam along in search of food. The habit of placing bits of

shells and sand on the tentacles is a common one. I have noticed it in a sand-living form on the California coast. As the tide went out and left the anemones dry, they were invariably covered with sand which adhered to the tentacles as though it had been gummed. To accomplish this protection from the hot rays of the sun, the anemone had picked up the atoms of sand with its tentacles and distributed them over its surface. As there were thousands of pieces, the amount of work may be imagined.

Anemones are found in many strange places. One, as we have seen, rides about upon the back of a hermit crab; another is so often found on the top of an ordinary crab that it is evidently a habit of the anemone. The anemone thus travels about with its host and shares its food. In the Indian Ocean a German naturalist found on every crab of a certain kind, which he caught, a sea anemone fastened upon the inside of the large biting claw. Thinking it accidental, he caught a number of crabs, but nearly all had the small anemone, which was so placed that when the crab raised its claw to its mouth to eat and tear its food, the sea anemone was in a position to obtain a full share of the food. Still thinking that this must be an accident, the naturalist placed a large number of the crabs bearing the sea anemones in a tank and removed the anemones with a knife, placing them in the water. The following day when they were examined every crab had its attendant again upon its claw. Again the experiment was tried, and again the crabs collected their curious attendants. The naturalist now cut one of the animals into several pieces, and even then the crabs attempted to collect them.

The anemones deposit eggs in vast numbers, which change into strange, free-swimming animals that finally settle upon the bottom and soon grow into the adult forms. They have another method of developing. Singular little "buds" appear on the sides and base of the adult, which soon resemble the parent. The anemone is very long-lived; specimens have been kept for nearly a century. They also have a marvelous faculty for renewing themselves if injured. If one is divided, sometimes two anemones will be the result, recalling their distant cousin the little hydra, which when turned inside out receives its food and eats as though nothing had happened. No amount of mutilating appears to affect its various portions, as each soon develops into a perfect hydra.

The sea anemone is a common form of the aquarium. It is easily secured by those living near the ocean, forming a most interesting pet, taking food from the hand, and soon proving itself possessed of a remarkable appetite. The anemones are among the great purifiers of the ocean, devouring a vast amount of dead matter which might pollute the water, and continually pumping the water through their systems, sifting out the animal life, dead or alive. Aside from this, the anemones are chiefly useful as beautifiers of the ocean. In the Mediterranean Sea they are sometimes eaten by the Italians and French. Certain fishes and crustaceans prey upon them.

V. THE CORALS

THE real gardens of the sea, the "Gulfs enchanted where the siren sings and coral reefs lie bare," are in the tropics, where the great coral reefs extend for miles in countless shapes, forming branches, heads, fans, and many forms which never fail to delight the eye of the observer. For many years I lived upon a coral key or island in the center of a coral reef. The key was half a mile in circuit, and was made up of coral sand, or sand composed of ground coral and shells. It was just above the surface, so near that almost anywhere salt water could be found a few feet below; yet in this sandy soil cocoanuts, bananas, and other tropical plants grew in profusion. A grove of bay cedars and mangroves added to its attractiveness and gave it the name of Garden Key.

The history of this reef is easily told. Ages ago there was no reef. There was no island, but perhaps a submarine plateau, a long distance below the surface. It gradually grew by the dropping of the minute shells described on page 15. After many ages it attained an altitude which brought its summit within one hundred or two hundred feet of the surface. Now its growth became more rapid as a new factor came upon the scene. The reef-building corals do not, as a rule, thrive or grow in water deeper than two hundred feet, and nearly all prefer water very much shallower. So, as soon as the submarine hill entered this zone, the eggs and young of the various

reef-building corals (Figs. 33, 37) obtained a foothold, and the growth was ever upward, countless forms aiding in it. The lower portion was continually dying, the animals occupying only the upper story, so that a cap of stone was being formed on the top of the hill which after

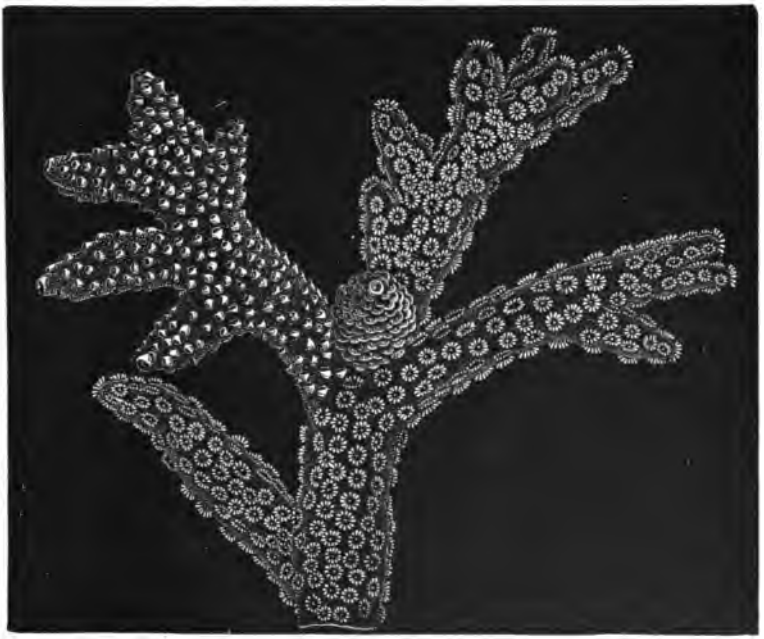


FIG. 33. — Branch coral (reef builder), showing polyps expanded and withdrawn.

many years reached the surface. The sea now broke up the tips of the branch coral. They became ground up. A curious seaweed which secreted lime appeared, and this and the ground coral and shells formed a muddy flat which, aided by various objects that float upon the ocean, constituted a miniature island. Now something which

resembled a cigar, one end downward, came floating along. If we could have examined it, curious little rootlets would have been seen growing from the lower portion. This stranded on the island, and the little cigar proved to be the seed of the mangrove tree; its roots grew and caught in the mud, and soon a tree appeared growing on the new-born island. Its roots presented a base, about which sand and mud rapidly accumulated, and so the key or island grew until it became the Garden Key of to-day.

Such is the history of an ordinary coral island, built up, not by corals alone, but by countless animals. Even to-day some writers describe this coral animal as an "insect," but it is an entirely different animal, being a polyp, so closely related to the anemones that very few can distinguish between them. For the purpose of examination we may

FIG. 34. — Mushroom coral; a single polyp (*Ctenactis*), one fourth natural size.

consider a coral animal as a sea anemone possessing the faculty of taking lime from the sea water and secreting it in the little rooms which we have found existing in the anemones (Fig. 32), there forming a little platform, then

partitions or cells, as the case may be. In Figure 33 is shown a section of branch coral. The starlike spots are the polyps with their tentacles outspread as in feeding. They may be considered so many anemones, each resting in a little cell, and all connected by a common brown or olive-hued tissue. This is a many-celled coral, while that shown in Figure 34 is an example of a single-celled coral, a huge anemone with a framework of lime. These single-celled corals are often found in very deep water.

FIG. 35. — A single polyp coral (*Caryophyllia*).

In the vicinity of Garden Key on the Florida Reef there are six or seven keys, each almost surrounded by a deep-blue channel. On the east a long fringing reef is forming which some day may form an atoll (Fig. 36). In this lagoon are acres of beautiful branch coral, rising two or three feet from the bottom in a mass of points almost bare at low tide, and at the very lowest tides becoming exposed and dying. At certain places on the edges of channels are vast heads of coral (Fig. 37), some being four feet high and six or seven feet across. Many of these are hollowed out into great vases and filled with beautiful sea fans, the

Gorgonias, in yellow, lavender, and brown, while in and out swim fishes of beautiful colors. The surface of these heads is often dotted with objects which resemble flowers of gorgeous hues, red, blue, white, and spotted. At the

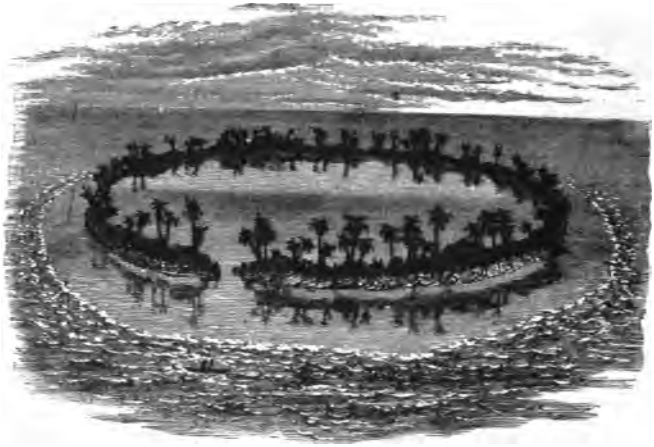


FIG. 36.—An atoll.

slightest alarm or jar these disappear, showing themselves merely worms, which have bored into the coral, the flower-like petals being the breathing organs. Along the sides of the channels the groves of branch coral (Fig. 33) dip down, and thirty feet below the surface the growth is much more vigorous, the branches often being three or even four feet in length, and resembling the antlers of the elk.

Wishing to see how deep the coral descended, I had a boat held on the edge of the channel, and taking a heavy stone in my hands allowed myself to sink. The stone carried me down rapidly for perhaps twenty feet, until the

water was perceptibly colder and the light very dim, yet as far below me as I could see, the almost perpendicular wall of coral extended, being in all probability sixty feet in height and almost vertical. As I swam upward not four feet from the jagged points, I could plainly see the beautiful coral with parrot fishes garbed in brilliant tints, poising among the great branches.

The coral on this reef grows or flourishes more or less in communities. The great heads are found in groups, the branch coral in plantations, if the word can be used, in the center of the lagoon and on the edge of the deep channels. On a shallow point, growing among seaweeds, I found small heads five or six inches long.

In the surf, where it piled in upon the reef, grew a beautiful form known as leaf coral, spreading out like

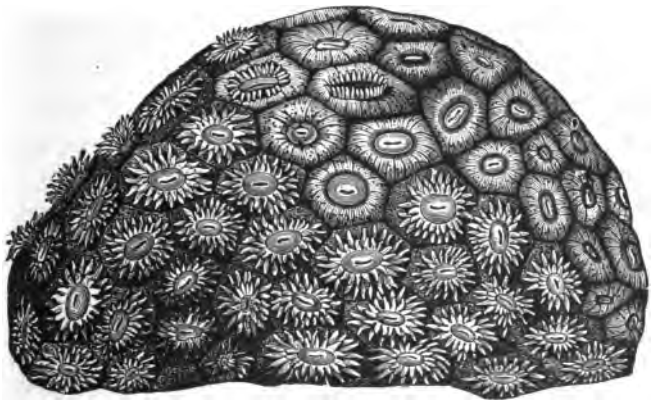


FIG. 37. — Coral head, with many polyps (*Astræa*).

the horns of the moose in great leaflike shapes. This crept near the ground, and was surrounded by its cousins, the Gorgonias, in lavender and yellow. The whole pre-

sented a beautiful appearance when seen from above through a water glass or glass-bottomed boat.

In most of these corals the branches were covered with the small cells of the coral animal, made up of thousands of individual polyps. Others again had very minute cells, yet the entire head might weigh a thousand pounds. Another large head is called brain coral, as the animals are arranged in deep trenches or convolutions. In the star coral (Astræa, Fig. 37) the polyps resemble stars and are much larger than those on other corals.

Occasionally I have found a branch of coral on which there was, perhaps, a bunch of eight cells, each half an inch across, the group resembling a bunch of flowers. These were generally in the deeper parts of the lagoon, where the water was fifteen or more feet deep, and therefore out of reach of the coral tongs. I would, therefore, dive down for it, the coral being distinctly visible in these clear and limpid waters. This rose coral, as we called it, was the work of a few polyps. Another kind was very delicate, the polyps being almost invisible. It was called pepper coral, as when tasted it burned the tongue violently. Still another, which grew in heads a foot or two across, had a peculiar habit of floating when free of animal matter. Large heads, when tossed from the beach where they had drifted, went sailing away like boats.

Still another coral has cells at short intervals up the branch; another is cup-shaped with a single polyp. One of the most remarkable corals (Fig. 38) has the cells of the polyps arranged after the fashion of a pipe organ, from which the coral takes its name, while the polyp itself, when expanded, resembles a daisy. Formerly

corals were supposed to be confined to the warm waters of the tropics, but this is true only of the reef builders, which require a temperature not lower than 63°, and are rarely, if ever, found at a greater depth than about 180 feet. Single polyp corals, like Fungia, are found at great

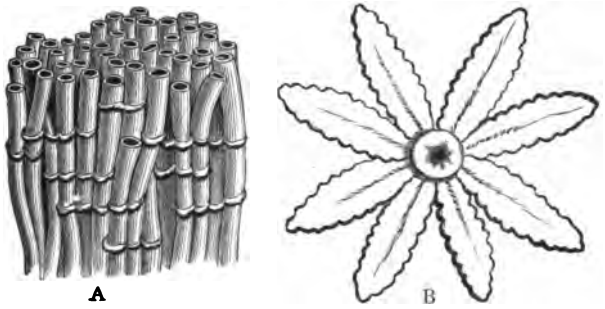


FIG. 38.—Organ-pipe coral (*Tubipora*): *A*, cell tubes; *B*, polyp expanded.

depths in the ocean, and certain corals grow in the Santa Catalina Channel on the Pacific coast. In the Atlantic, as far north as Long Island Sound, where the water is often icy cold, is found the beautiful Astrangia, a coral in which the polyps are pure white and about five one-hundredths of an inch in length.

In a general way we have passed in review some of the typical corals, and may now glance at their manner of growth. If we cut one of the cells of a coral across, we shall have a figure similar to that shown in Figure 39. The white radiating partitions are coral, the black spaces are rooms, which correspond to the little apartments in the anemone. The coral develops by eggs and by budding, just as in the case of its cousin, the anemone. The eggs, after enjoying a free-swimming life for a while,

settle upon the bottom and begin to secrete lime. They do not build up a house as the mythical "coral insect" is described as doing, but secrete it much as any animal secretes its bones or shell. As the water flows through the animal it is enabled to secrete the lime dissolved in the water. If we could watch every step of the growing process, we should first see a little platform of lime attached to the stone or object upon which the young coral animal has dropped, then a little edge or rim which increases in

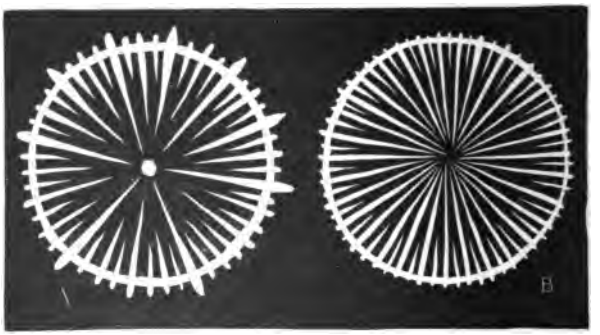


FIG. 39. — Sections of a coral cell.

size daily. Out from this rim shoot the partitions, as shown in Figure 39. It will be observed that they do not meet and join, but leave a place in the center for the stomach. Finally, the cell is completely formed, and we have a perfect cup of lime, a coral cell in which is ensconced the anemonelike coral polyp. Its color is an olive brown, and when the polyp is expanded its little tentacles resemble the petals of a flower. With these it catches food, which it eats in very much the same way as do the anemones. If this cup is a branch coral, soon a bud

appears upon the side, and a new cup or cell takes shape. Then another is added, and we see the coral enlarging, branching out either by budding or simply dividing until a large branch is the result.

This growth is much more rapid than is generally supposed. The brain coral has been known to grow an inch or double its size in a year, and branch corals grow six or eight inches in this time. The corals and reefs form the great girders of the globe. The one off Australia is over a thousand miles in length, and all over the world are found fossil reefs. Thus in the Helderberg Mountains of New York I have followed and traced a coral reef, quite as wonderful in its way as that now growing and reaching out in Florida. By some upheaving of the earth's surface it has been pushed up into the air, a monument telling of the wonderful changes in nature and of the time when the waters of New York were as warm as those of Florida.

Side by side with the corals and among the most beautiful objects of these submarine gardens, we find objects which resemble plumes and fans (Fig. 41). These are called Gorgonias, and are cousins of the corals. They resemble fans made up of a fine network or reticulated surface (Fig. 40). They are richly colored yellow, brown, and lavender, those of the latter color being particularly beautiful. When there is a surf they can be seen waving and bending gracefully, like the limbs of a tree

FIG. 40. — Surface of sea fan, enlarged.

FIG. 41.—Sea fan (*Gorgonia*).

in a gale. One of the best known of this group is the red coral of commerce, found in the Mediterranean Sea and the Indian Ocean. When alive, the coral base or branch is covered with a crust or skin in which the animals live, connected one with another. The polyp stands very high and is white. The crust itself, the solid lime base, is formed of a number of minute parallel tubes. This coral is dredged by collectors in the deep water and is scraped and polished until the beautiful red color, so highly prized for jewelry, is brought out.

Closely allied to the corals are the sea pens (Fig. 42) which are common in almost all waters, and among the most beautiful forms. They are communities of polyps. In the sea pen the polyps are arranged along the branches so that a fluffy fan or an ostrich plume is imitated. I have taken these animals from deep water when they measured perhaps five

FIG. 42.—Sea pen.

inches in length; but an hour later when placed in a tank the insignificant animal had expanded until it was five times as large, and beautiful beyond description in its garb of delicate pink. At night it was a blaze of light which flashed from branch to branch, from polyp to polyp. When irritated in a perfectly dark room this specimen created so brilliant a phosphorescent light that I could almost read large print by it.

FIG. 43. — Veretillum, a wonderful light giver.

In the deep sea lives a giant form, the Umbellularia, four or five feet high; and there are many more, all of which add to the lights of the deep sea. Near allies of these attractive forms are the comb bearers, free-swimming, jellylike forms of great beauty and grace. I have kept the radiant Pleurobrachia in a tank where I observed its wonders and beauties. The one known as Veretillum (Fig. 43) is very beautiful and a marvelous light giver.

VI. THE STONE LILIES

A NUMBER of years ago I took a number of walking trips over that section of New York state known as the Catskill Mountain region. The start was made at the mouth of Catskill Creek, which was followed up into the mountains until we came to a peculiar light, slate-colored rock. This rock, where the stream had washed the earth away, was dotted with little disks (Fig. 44), which being harder than the rock itself had been weathering, and stood out in high relief. A mile or two from the river the rocks were covered with these disks, in fact, seemed to be made up of them. Some were large, some small, as if millions of pipestems had been cut into sections and scattered about.

FIG. 44. — Sections of fossil crinoid stems, Catskill Creek.

These disks told an interesting story. We read by them that ages ago the region now covered by farms

and summer resorts was the bottom of a shallow, tropical sea. We could go further and describe even the appearance of the bottom of that sea, and what grew and lived there. Scattered about on the rock were myriads of shells, corals, teeth, fish bones, and a variety of objects, all the remains of animals which once lived in this ancient ocean.

We find that the little disks fit together, and collecting them, pile them up, forming a stem a foot or more long. Among them we find one which is attached to a rootlike object, and this is placed at the bottom. Near by we find a flowerlike or budlike form (Fig 45), which may well serve as the flower of this stem, and so we add it and produce a striking resemblance to the crinoid shown in Figure 46. This is an interesting and beautiful animal which was one of the commonest forms of the ancient seas. It grew in groves and masses, as we may see by the vast numbers strewn in the old ocean bed; and when they died, they were scattered here and there and hardened into the old bed.

FIG. 45. — Fossil crinoid.

The crinoids resemble lilies so closely that they are called stone lilies. They are animals, however, related to the starfishes. They have a long stem, with rootlike branches to support it, and are capped with what appears like an inverted starfish, and is literally a starfish perched

FIG. 46. — A living crinoid (*Pentacrinus*).

upon a stem. Fossil crinoids have long been known, and beautiful specimens may be seen in all our museums, but the fact that they still live upon the globe is a modern discovery. It is said that Agassiz stated that he expected to find them alive off the coast of Cuba, and when a deep locality was dredged, up came the living crinoids, or forms almost identical with them. Since then they have been dredged in great numbers by all the great deep-sea explorers. Some have long stems, some short. On one, the Comatula, when it is full grown, the crinoid.

leaves its stalk, and lives a free, roving life after the fashion of many starfishes.

The crinoid, with its long slender stem, its branching tendrils, its flowerlike top, is one of the most graceful of all animals, as might be imagined from the drawing. Examine the crinoid as closely as one may, it still resembles a stone lily, and only its slow movements, contracting and folding, suggest life. Nevertheless, it is a very complicated animal. It consists of a central body, protected by numerous plates, as seen in Figure 46. From the edges extend five, or often more, branches or arms, and from them in turn branch other arms, so that the top resembles a feather or brush, from which they are called feather stars. In the center of the stars is a mouth, food being caught by the many branching tentacles. The history of the development of crinoids is very interesting. They pass through several curious stages in the course of growth from infancy to old age, and some of the shapes are so curious that no one, not familiar with them, would suspect that here was a growing crinoid.

VII. THE STARS OF THE SEA

BENEATH almost every rock along the New England coast, and under the branch coral in the tropics, we may find a typical star-shaped animal, and by dredging off-shore, thousands are brought up, even from very deep

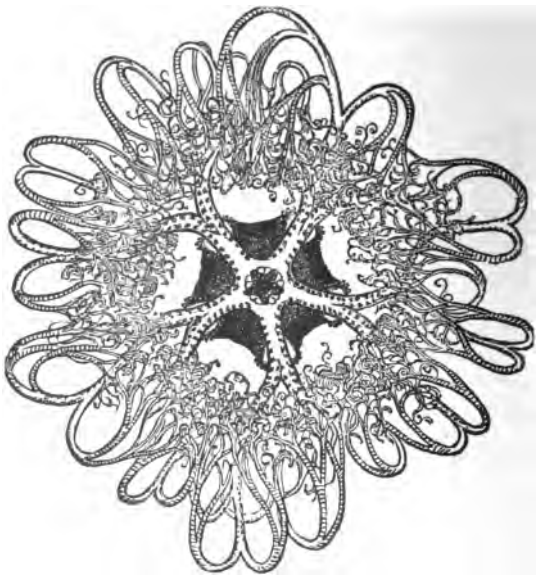


FIG. 47. — Basket starfish.

water, showing that the stars of the sea are almost as plentiful as they appear in the sky above. These star-fishes are of all shapes, kinds, and colors. Some are a foot or more across, huge, domed fellows with rough backs,

showing little if any signs of life (Fig. 48); others have five long legs and a small body (Fig. 49). Others, again, are perfectly round and have many rays, while some have few rays which are round, like the body of a snake, and

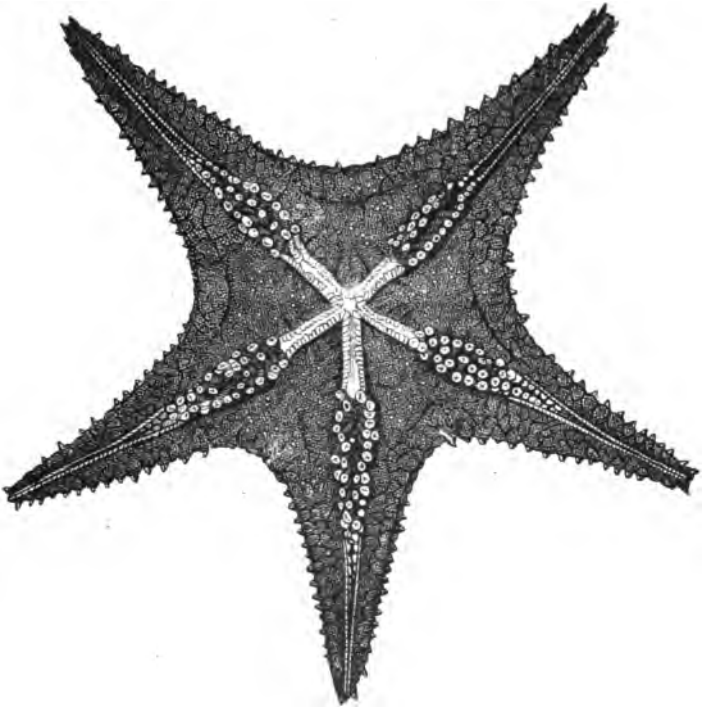


FIG. 48. — Lower surface of starfish (*Goniaster*), showing suckerlike feet; a slow mover.

which they whip and slash about, displaying great activity. Once in reaching beneath a coral branch to find a certain shell which I knew lived there, my hand grasped something which felt like a ball of snakes, each of which closed about it, producing a most disagreeable sensation. I drew

it out and found it was one of the starfishes, common on many shores as the basket starfish (Fig. 47). As I lifted it up it was a veritable mass of coiling arms, a Medusa's head of the sea, coiling and uncoiling. It was merely a starfish in which each arm branches in two parts, each

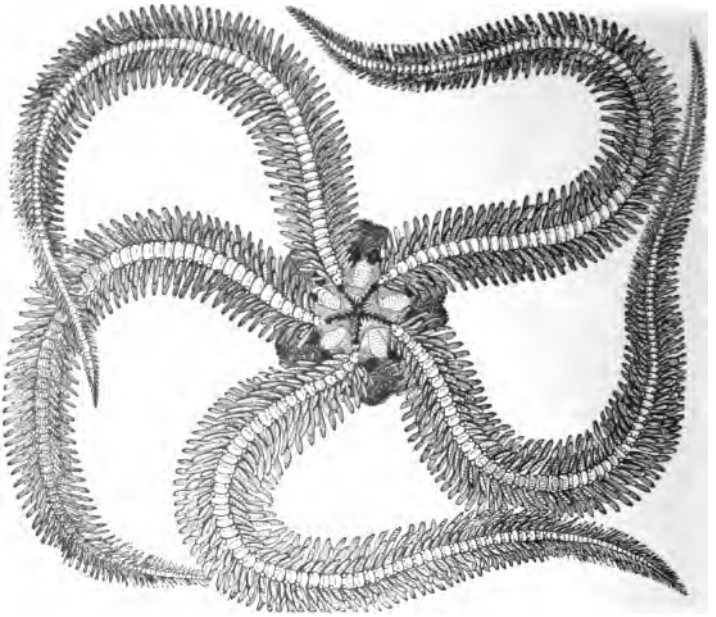


FIG. 49.—A deep-water starfish (*Ophiocoma*), a rapid mover.

branching out into two again with the result pictured, a confused mass of arms. As I lifted my capture above water and it felt the air it began to shed its arms, so that it fairly rained pieces of starfish, and before I reached the boat, but a few feet away, all that remained was the body. My starfish had almost committed suicide.

The starfishes are found everywhere in the tropics. Every bunch of coral contains scores of them. Many resemble spiders, and are a vivid red hue, others are bronze or brick red, while still others are barred or spotted, as in Figure 50. They are all interesting creatures, especially our common Eastern starfish, which is found in little caves at low tide, clinging to the walls. It is not very attractive in appearance, and apparently not disconcerted by being left by the tide.

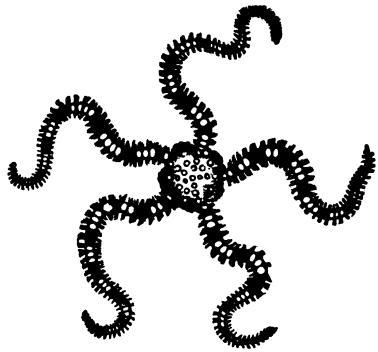


FIG. 50. — A brittle starfish.

If we take a common starfish and turn it upon its back, we observe that the lower portion is covered with short tentacles, each having a little sucker on the end. These are the feet of the starfish, by which it walks or moves. In the center of the body is the mouth leading into the stomach which reaches into each ray. The eyes are at the tip of each ray. On the back of the star we find a little red disk with a rough surface. This is really a sieve for straining the water which pours in through a little canal encircling the mouth and leading off into each arm, carrying water to each one of the myriads of feet.

The feet move independently, and the starfish walks much faster than would be imagined. This can be illustrated by the sudden appearance of the starfish, in Long Island Sound. One night when the oyster men left the

beds no starfishes were seen. The following day they were there in such vast quantities that it was estimated they covered the entire bed, two or three deep, and tens of thousands of dollars were lost by the destruction of the oysters.

How an oyster can be opened by a soft, helpless starfish would seem a mystery; but it is a very easy matter. The starfish drags itself over the shell and places its mouth at the end, extending its long arms downward, literally swallowing part of the shell. It is supposed to eject some secretion into the shell that causes it to open.

VIII. OCEAN HEDGEHOGS

(*The Echini*)

On the Florida Reef and off the rocky shores of California one of the most conspicuous among the rock-living animals is the black, long-spined Echinus. In the water it looks like a huge pincushion (Fig. 51) filled with black

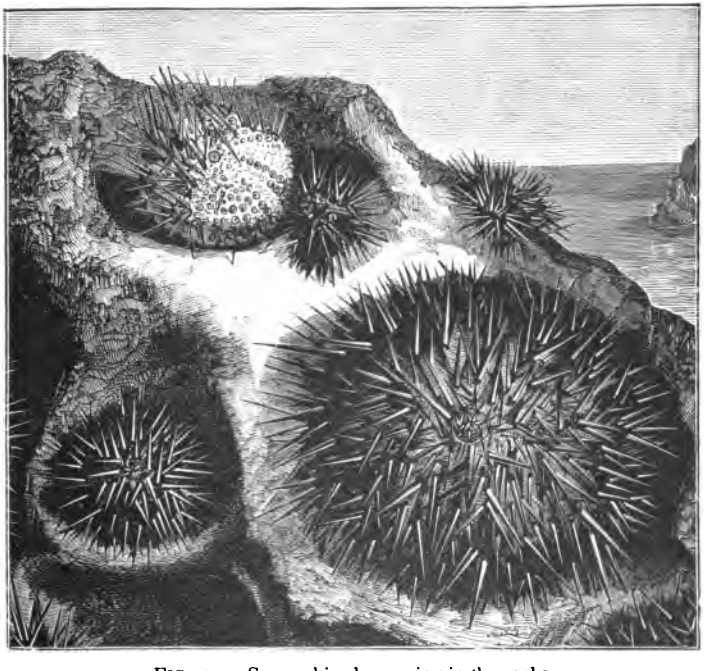


FIG. 51. — Sea urchins burrowing in the rocks.

pins, points outward, and every crack and crevice is filled with them. When found on the beach, despoiled of their spines, they resemble bleached shells, and are then known in Florida as sea eggs (Fig. 52). The long black spines are continually moving up and down, and constitute the armament of the sea urchin, and an effective one to all except very large fishes, as some rays, which have pavementlike teeth fitted particularly for such not especially dainty morsels. The spines emit a bluish secretion which is left in the wounds made by them, and is more or less poisonous. This common sea urchin is a type of hundreds found in almost all seas from very shallow water to the abysmal regions of the ocean.

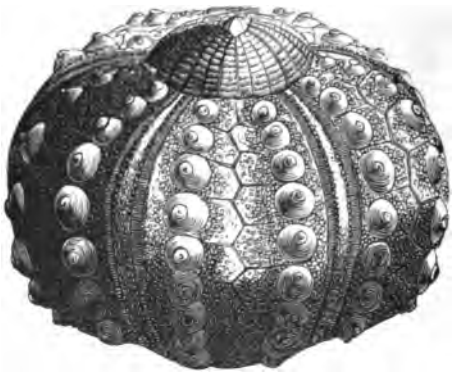


FIG. 52.—Sea urchin without its spines.

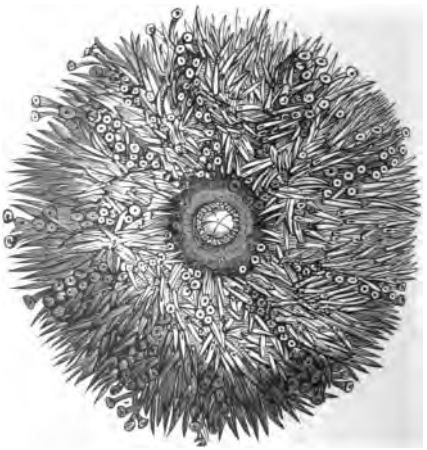


FIG. 53.—Short-spined sea urchin, showing the biting teeth.

Some sea urchins have short spines (Fig. 53) and are almost pure white ; some are flat like the sand dollars, the spines feeling like sandpaper, so short and fine are they. The latter are small, and appear to be covered with waving filaments. Many have spines like needles ; in others the latter are blunt, clublike organs. Many other strange variations are seen in an exhibition of the various kinds in some museums. None are more remarkable than those having five holes through them like Chinese money (Fig. 54).

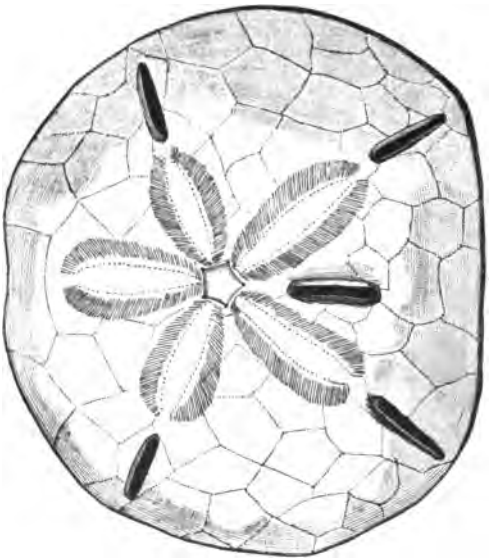


FIG. 54. — Flat sea urchin, "sand dollar."

The urchins are very closely allied to the starfishes, especially in structure. They have the same kind of feet, and among the spines is seen a singular handlike organ common to the starfishes. It has three fingers (Fig. 55) and a short stem, and is constantly in motion, its office appearing to be to clean the body. Foreign objects are taken up by this peculiar hand and passed on from one to the other until they are finally dropped off. Here is the same madreporic plate or sieve,

and the structure of the Echinus (Fig. 56) is very similar to that of the starfish. The former has a long set of jaws, hence is a biter and nipper, while the starfish is a sucker. The shell of the Echinus is really a beautiful object when

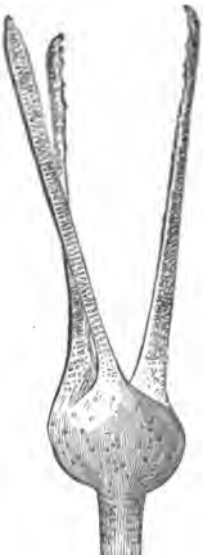


FIG. 55. — Handlike organ of sea urchins and starfishes.

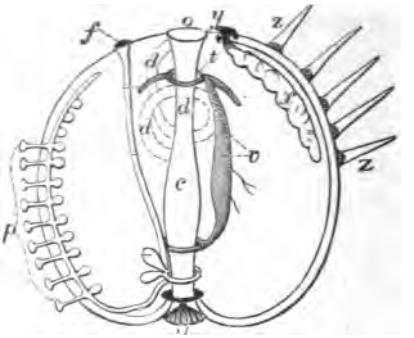


FIG. 56. — Structure of the Echinus: *a*, mouth; *o*, anus; *c*, stomach; *f*, madreporic plate; *d*, intestine; *p*, ambulacra; *v*, heart; *z*, spines.

divested of the spines and bleached in the sun, appearing as pure white as coral after bleaching. It is made up of about six hundred hard, limy plates arranged in double rows, which contain about thirty-seven hundred pores through which the feet protrude. Despite this marvelous supply of feet, or organs of locomotion, the Echinus is a very slow walker. The spines number four thousand or more, and each one works on the ball-and-socket plan, is hollow, and moves readily in all directions.

The sea urchin is produced from eggs. The young pass through some remarkable changes before they assume the adult form. In one of these changes they appear as free-

swimming animals (Fig. 57), and resemble anything but the perfectly developed Echinus. Some of the sea urchins of deep water, as the Hermiaster and others, carry their young in pouches, the spines being folded over them to hold them in place. They rarely move from the crevice on the rock which they select. They can be found in the same place for months together, and have a limited power of wearing out the rock. How the Echinus grows inclosed in so hard a shell might be a puzzle did we not know that the shell is covered with a skin, each plate being literally surrounded by it. This skin secretes lime, taking it from the water and depositing it on the edges of all the plates, so that the animal grows rapidly and symmetrically. The Echini are the scavengers of the ocean, and they aid in maintaining the clearness and purity of the water. In some countries certain kinds are eaten, and one species is valuable for its spines, which are used as slate pencils.

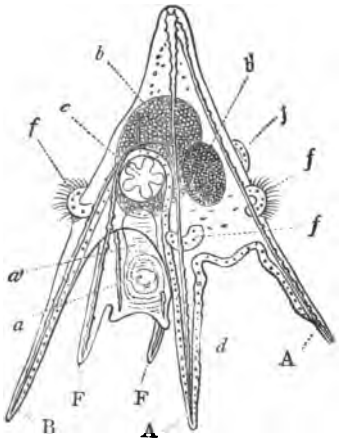


FIG. 57. — Young sea urchin.

IX. THE SEA CUCUMBERS

ONCE, when poling my boat over the great coral reef of the outer Florida Keys I came upon a little plot of sea-weed in shallow water which was so covered with huge sea cucumbers (Fig. 58) that it would have been an easy matter to fill the boat. They were from six to twelve inches in length, two or three inches across, and bore a striking resemblance to actual cucumbers. In color they were brown, and when lifted from the water they slowly moved or twisted, sending out a stream of water. They might have been made of leather, so far as any evidence of life was concerned, and were so tough that a

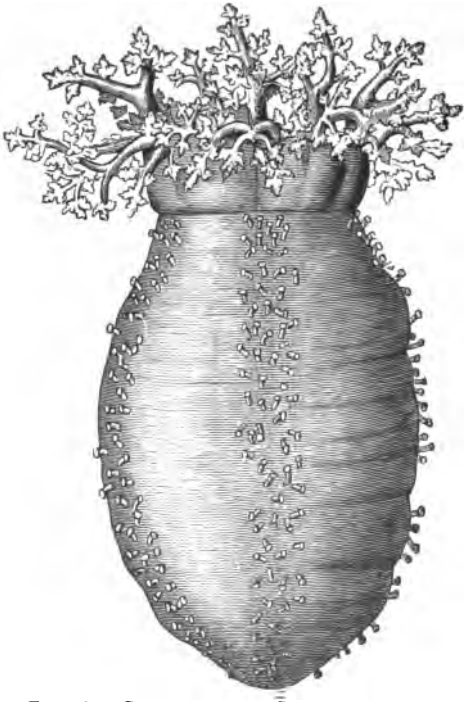


FIG. 58. — Sea cucumber, showing its breathing organs.

spear thrust into one had to be cut away, so tenacious was the hide of this singular sluglike animal. Taking a large one from the bottom, I placed it in a glass jar standing on the deck of my boat, whereupon a very singular occurrence took place. When the air began to be exhausted in the water of the glass, out from the sea cucumber came a long, slender fish, so ghostly and ethereal that when it died, as it did almost immediately, I placed it upon a piece of newspaper and read print through its body. The fish was known as Fierasfer, and it lived in the long intestine of the sea cucumber. Since then the fish has been closely studied in the Naples Aquarium, where it had the same habit, and where the attendant naturalists saw the fish come out, and return tail first.

The great sea cucumber of Florida may be taken as a type of all the group which differ mainly in size, color, and shape. Some are very short and have a decided flat lower surface; others are long, fragile, and easily broken; and many are brilliant in color. Nearly all are famous for their singular and often beautiful breathing organs which protrude from the mouth and bear the most remarkable resemblance to plants. In many specimens of the Atlantic Pentacta (Fig. 58), kept in an aquarium, this resemblance was very marked, as the animals at once buried themselves in the sand from which beautiful plants seemingly grew, being merely the breathing organs of the wily mimic. These organs vary much in size and beauty. In some species they are very elaborate, in others they are simple, flowerlike objects. The greatest variation is found in them. In one which I observed the tentacles resembled small toadstools.

Many of the sea cucumbers, or holothurians, are very sensitive, and when captured will often cast off their various organs. This does not indicate the death of the animal, as they are soon replaced. A singular trait of the long glasslike Synapta is that of cutting itself in two when starved. At first an end of the animal is dropped, then another piece, and this is continued until nothing but the mouth remains, everything having seemingly been sacrificed to save this portion. If food is now supplied, this animal will soon recover and assume its normal condition.

Synapta has no feet, their place seemingly being taken by peculiar limy spicules, shaped like anchors (Fig. 59), which are deeply buried in the skin. In its structure the sea cucumber resembles its cousins the starfishes and sea urchins, and standing on end, may be compared to an elongated sea urchin. Nothing can be more uninviting than these animals, and when dried the flesh has the consistency of leather. Yet the sea cucumber is highly regarded by the Chinese as a delicacy, and the Malays have a large fleet engaged in the business of gathering and preparing them. The animals are collected and dried, then smoked and packed in bales and sent to China. They may be found in any of the markets of these people, in San Francisco and New York. About the Pacific island of Santa Catalina they are very commonly seen through the bottom of the glass-bottomed boats, lying in the seaweed and imitating it in color.

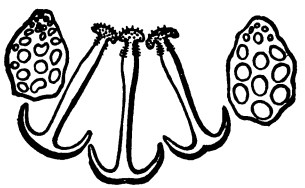


FIG. 59.—Anchorlike spicules of Synapta.

X. THE WORMS

FEW groups of animals differ so much in general appearance as the worms. Some resemble miniature snakes; others are flat, some are like needles, one lives in a cell; another stays in the tissue of some animal, while certain others infest the soil. Almost everywhere, on land and in the sea, under nearly all conditions, we shall find these remarkable creatures, which may be briefly described as animals having a head, tail, and upper and lower surfaces, and made up of a great many rings, or segments. In them we find an approach to the higher animals. Thus they have a heart, with red or green blood, breathing organs, though many breathe through the body walls, and a nervous system consisting of a minute brain in the upper portion of the small head.

All the worms deposit eggs, and nearly all are remarkable for the wonderful changes through which they pass before they attain maturity. This is well illustrated in a planarian worm (Fig. 60), which seems to require the presence of another animal to enable it to complete its develop-

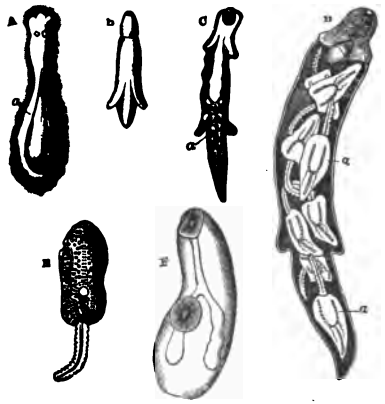


FIG. 60. — Development of a planarian worm.

FIG. 61. — A flukeworm.

ment. The little creature which breaks from the egg (A) is a free-swimming creature surrounded by cilia or hairlike swimming organs. By these it moves through the water, and with strange instinct searches for some animal, generally a snail, which it enters. There it becomes surrounded by a sack and produces a little creature called the nurse (*b*), which soon grows to resemble the tadpolelike creature (C), which is filled with small egglike or germlike objects (*a*). It now changes into a wormlike creature (D), in which the germs have assumed the shape of worms (*a*), and soon breaks forth as a little form with a tadpolelike tail (E)—a remarkable performance. But the end is not yet; another animal is necessary to complete the change. Swimming about, the little creature is swallowed by some animal in drinking, and finds its way to the liver, where it lives, the tail being lost. The animal now changes into a perfect flukeworm (F),

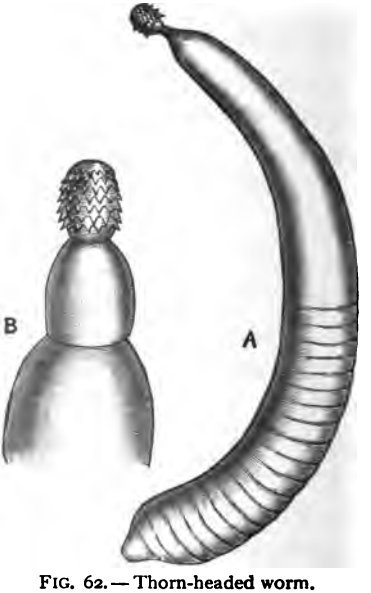


FIG. 62. — Thorn-headed worm.

which finally leaves the animal or host and lays eggs in the water; these pass through the same wonderful transformation. The flukeworms (Fig. 61) are disagreeable flat creatures, not often seen, the marine forms attaining large size.

Many of the worms are parasites living upon other animals. The thorn-headed worm (Fig. 62) is an example. Who has not heard the story of the living horsehair? Almost every country newspaper has told the story, that some farmer after washing his horses had found several hairs taken from the horse's tail which "were alive," and to prove the story the farmer produces the "living horsehair" which is a remarkable imitation of the long hair of a horse's tail. But the hair is a well-known worm (Fig. 63) called Gordius aquaticus. It is almost exactly like a horse's hair, two or three feet in length, and found coiled up in ponds or snugly tucked away in the interior of a beetle or grasshopper which it has seized upon as a host. The deadly Trichina spiralis belongs to this group (Fig. 64). If the vinegar bottle is examined, in what is popularly called the "mother" at the bottom, still another member of the family will be found. This is a minute round worm almost invisible to the naked

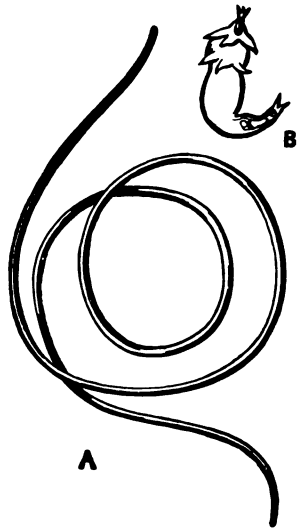


FIG. 63. — Supposed horsehair worm (*Gordius*): *A*, adult; *B*, young (larva).

eye. It is very active and disagreeable to contemplate, living in the sour, fiery liquid.

In this group are many dangerous worms, as the guinea worm of remarkable length. While nearly all worms are disagreeable creatures, a few are very beautiful. Such

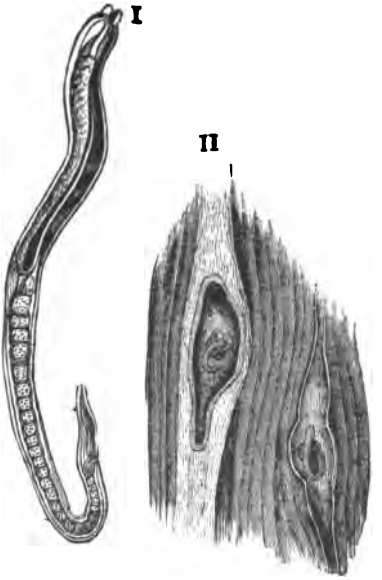


FIG. 64. — *Trichina spiralis:* a deadly worm from pork.

FIG. 65. — The rotifer.

are the rotifers or wheel animalcules (Fig. 65). These are the smallest and most active of the tribe of worms. To be found they must be sought in a drop of standing water, and as they are rarely ever over one thirty-sixth of an inch in length, a microscope is necessary. Among the throng of wonderful creatures one will be seen seemingly rolling over and over like a barrel, a minute whirling

Dervish of the water. The rotifers assume a variety of shapes. One is a typical worm, another darts along by the aid of two circlets of cilia which vibrate so rapidly that the illusion of rolling is produced. No more wonderful creatures than these little worms are known, and they well repay the study required to know them well. Some of them are fixed and unable to swim, and many of the stories of spontaneous generation are due to the faculty these

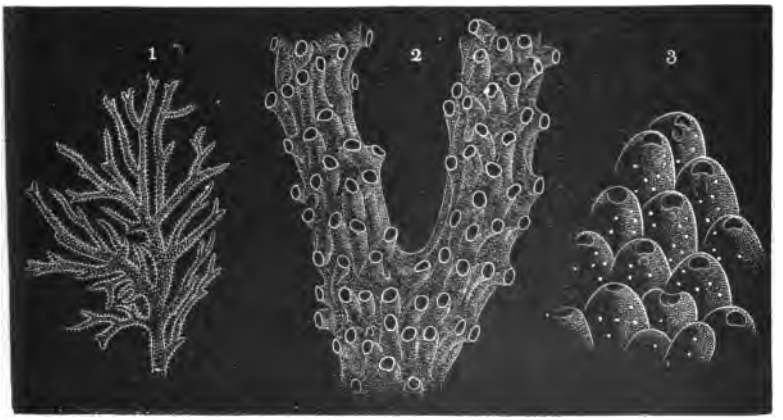


FIG. 66. — Polyzoans: 1, colony in plant form; 2, 3, cells of the worms magnified.

minute rotifers (often but three one hundredths of an inch in length) have of enduring almost any amount of drying. Thus if a pond is dried up by the sun, the rotifers seem to be able to lie dormant for a long time, and when a rain falls in the locality for the first time in years, the pool is at once peopled with rotifers which awaken from their long sleep. When it is known that Ehrenberg, the German naturalist, found that a certain species produced sixteen million young in less than two weeks, it is easy to under-

stand how quickly a new pond might become rapidly equipped with a large population.

It is a singular fact that myriads of worms are seen daily, but are not known as such. These are the minute and beautiful Polyzoans (Fig. 66). They are marine animals, grow in colonies, and look like delicate seaweeds. They are often called moss animals. At the seashore we shall find the rocks and particularly the broad fronds of kelp near shore often encrusted with a delicate, beautiful tracery of pure white. In California I have found the kelp leaves at the surface covered with it, having the appearance of being coated with silver. Beneath the glass it develops into a beautiful tracery filled with cells. When magnified these cells are seen to resemble Figure 67, each one having its worm, which seems to blossom like a flower. These worms are minute imitators of corals, as they form a corallike structure, the worms having the faculty of secreting lime, as do the corals, yet they are much higher in the scale of life. One of the common seaweeds of the seashore is the sea mat or Flustra. No one would suspect it of being other than a beautiful marine plant with large leaves or branches, and many a collection of "seaweed," preserved through many years, contains the Flustra arranged among the real "plants" of the sea. But Flustra is merely a

FIG. 67.— Polyzoan, magnified.

colony of worms. The minute spots seen upon it when enlarged beneath a microscope resemble so many cells of carbonate of lime secreted by the worms of the community or colony. Another species of Flustra is shown in Figure 68, and a part of the skeleton of the colony or of each cell is the peculiar bird's head which has a beak. This beak, even after the death of the worm, is seen to open

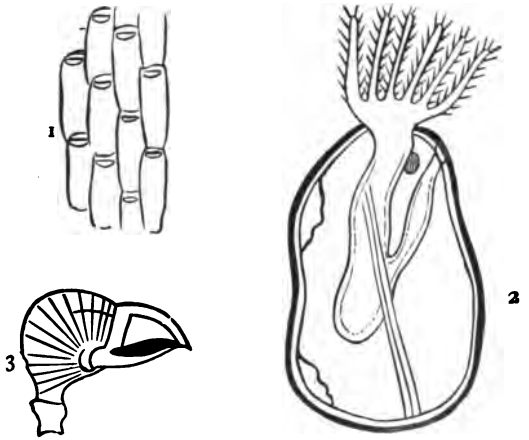


FIG. 68. — Bird's-head Flustra: 1, Flustra mat, showing cells; 2, diagram of a single worm (*Polypide*); 3, bird's-head process.

and shut, snapping continually, much quicker than the little pincerlike objects we have seen in the sea urchins. The use of the so-called bird's head is not well understood.

This Flustra (Fig. 69) is very beautiful, forming a delicate little plantlike form about an inch and a half in size. But the crowning glory of these worms, as shown in the figure, is the circular crown of tentacles by which food is grasped as it passes by. Any one who has collected fossils in what is known as the Trenton limestone is

familiar with the little fossil shell called Lingula, of which two thousand species are known. Curiously enough this little shell has come down to us to-day, and in Figure 70 we see the living Lingula of our waters with its long stem by which it fastens itself in the sand. Lingula resembles a small clam shell, has two perfect shells, and probably holds a place in many collections as a shell; yet Lingula

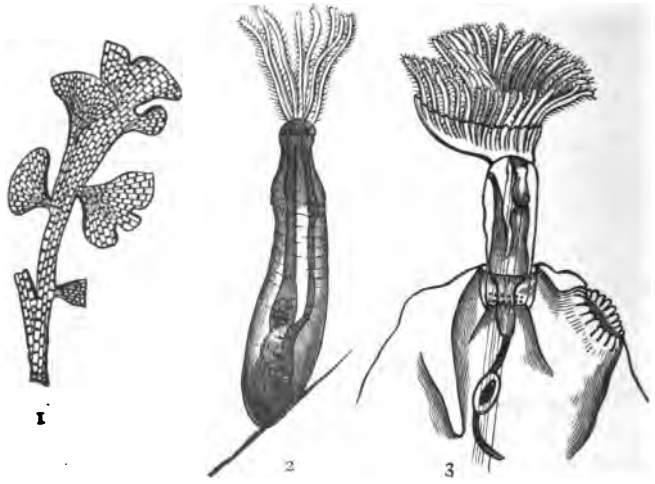


FIG. 69.—Sea mat: 1, sea mat, natural size; 2, 3, section of the animal much enlarged.

is a worm which secretes a two-valved, unhinged shell, that is an almost perfect imitation of a bivalve mollusk. In the Santa Catalina Channel, California, from water six hundred feet in depth, I have dredged shells resembling those in Figure 71. They hung upon rocks in clusters, and were very striking in their rich colors of yellow, red, etc. In shape these Terebratulas, also common among the fossil shells, resemble ancient Roman

lamps, and hence are called lamp shells. They too are worms, however, and many more shell makers called brachiopods. The "wick," a muscular stalk or byssus, becomes firmly attached to some object at the bottom. But in the instance of the little Lingula the stalk or anchor rope merely passes between the curious shells. If the latter are opened, we find a singular bridge or limy framework which is intended to support the soft parts of the bridge, a very conspicuous feature of which are what are called arms, long, ribbonlike, fringed processes (*a*) which are coiled up in the shell and serve as breathing organs and to obtain food as well. They can be extended some distance from the shells. The curious frame upon which they rest is well shown in Figure 72. It is on record that during the Sikh rebellion an entire English regiment was put to flight by a force of worms. The troops were marching

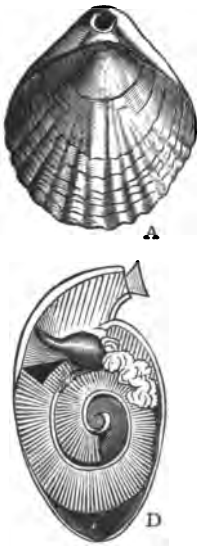


FIG. 71. — Lamp shells, showing gills.

FIG. 70. — Lingula.

FIG. 72. — Brachiopod, showing supporting loop.

through a forest when land leeches began to fall from every branch and leaf, dropping in such vast numbers that the men were almost crazed by the vicious bloodsuckers; hence they broke and ran for clear ground, where they could rid themselves of the terrible pests. Semper, the naturalist, states that he was driven from the forests of Luzon by these leeches, which fell upon him like dew. The ordinary leech of commerce (Fig. 73) belongs to this group. It has a sucking mouth, which bears three teeth. It was once much used by physicians for bleeding purposes, in fact, the animal derives its name from the fact that medical men in England were formerly called leeches. The leech had a high commercial value, over seven million being used in London in a single year, valued at ten dollars a thousand. Leech raising is a regular business in Russia, Bohemia, and Hungary.

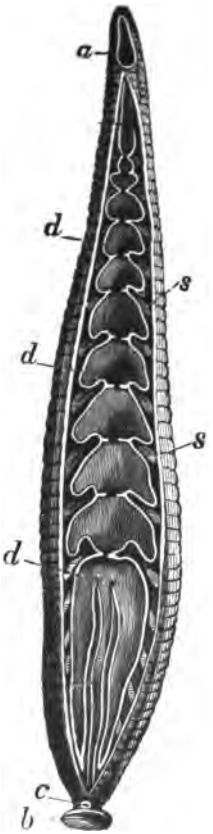


FIG. 73. — The leech of commerce: *a*, anterior sucker; *b*, posterior sucker; *d*, stomach; *s*, glands of the skin.

The best known of all worms, perhaps, because all boys are fond of fishing, is the angleworm or earthworm (Fig. 74), which can be found where the earth is rich and moist. This worm is really a beautiful object, being highly iridescent, flashing a thousand hues in the sunlight to which it has a decided objection, as the heat soon dries

it up. The ringed or segmented arrangement is easily observed as it moves along. By this marvelous arrangement a worm can either stretch itself out to an inordinate length, or telescope itself until it can hardly be recognized as a worm. There are several interesting features about earthworms which ordinarily escape the notice of even the angler. One is its feet, which differ from those of any other animal. They are very minute, and are bristles, each segment or ring being supplied with four. Another peculiarity of the earthworm is that instead of hunting out food in the earth it swallows the earth as it meets it, allowing the animal matter to be absorbed within. It then casts up the earth, which are the little mounds of mold found in the grass or turf every morning. This habit has made the worm a valuable aid to the farmer in preparing the soil, filling it with tunnels and constantly bringing new earth to the surface and turning it over. The amount of earth moved in this way was made a special study by Charles Darwin. In the year 1842 he spread a field with broken chalk, and after twenty-nine years examined it and found that the chalk in that time had been buried seven inches by the worms.

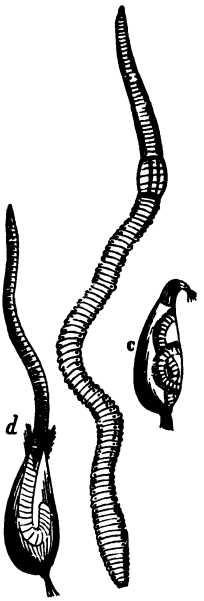


FIG. 74. — Earthworm: *c*, egg; *d*, young escaping from egg.

This gives us some idea of how important a factor these humble creatures are, working mainly at night, in burying

the works of man. It is evident that in two or three centuries portions of buildings could be concealed. In England numbers of ancient Roman villas have been discovered, beautiful floors and foundations of ancient buildings which have been lost to sight by being covered by these night workers. To give an adequate idea of the work they accomplish, Darwin says that the amount of vegetable mold brought to the surface in a single year amounts to ten tons to a single acre. They rarely descend below six feet, and Darwin estimated that in favorable localities there are 100,000 in every acre. In New Zealand 348,480 have been found in a very rich acre. The worms eat the earth, and drag leaves and soft twigs into their holes at night. They plant seeds and bury stones. Some of the casts of giant worms of India are a foot in length. They live entirely beneath the ground, lining their burrows with very soft fine earth, which appears to be powdered for the purpose. All their operations are carried on at night, when they come to the surface and eject the casts. They have a habit of lying near the surface at the entrance of their burrows, a fact which the birds have discovered, robins and mocking birds particularly being very clever in hunting them out.

One of the most remarkable features of these worms is their phosphorescence, which I have found is more brilliant than that emitted by any other animal. Crossing an orange grove in southern California one dark and rainy night in January, I stumbled over a clod of earth, and if I had kicked a mass of live coals, the result could not have been more marked, as flashes of vivid light darted in every direction with the earth, caused by several earth-

worms which had exuded so much phosphorescent matter that it had pervaded the entire mass of surrounding soil. The phenomenon on a small scale can often be seen in southern California, especially in winter, when the ground is moist and wet.

Probably the most beautiful of all worms are those of the sea, the marine forms found everywhere from the mud banks to the long fronds of kelp washed by the

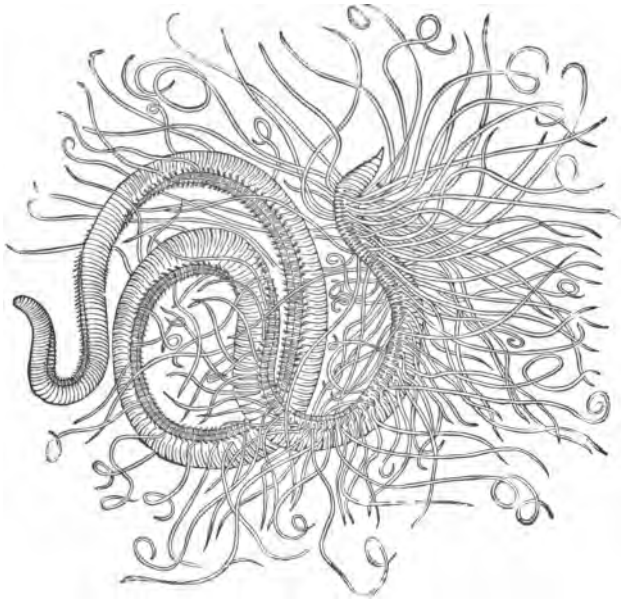


FIG. 75. — Marine worm (*Cirratulus*).

foaming sea. Perhaps the most gorgeous creature taken from deep water is Aphrodite, several inches long, an inch across, and about the size of a mouse. The worms are provided with an array of iridescent bristles, so beautiful as

to appear artificial, blazing with golden lights. Some of these worms are covered with strange and brilliantly colored streamers, as Cirratulus (Fig. 75). Others are long and slender, as Nereis (Fig. 76), a very common form alongshore. It is sought after by fishes with good appetites, and often caught, despite the fact that it has four eyes, four hundred paddles, and fierce jaws for seizing prey. Nereis lives in the sand in a tunnel. It has a habit of coming out at night and swimming abroad, when, creating a blaze of light, it becomes a very conspicuous object and is quickly caught by some wandering fish. These worms are among the most brilliant of all light givers; not alone for the intensity of light, but for its variety in tint and color. The most remarkable light givers are Polynoë, Syllis, Chætopterus, and Polycirrus. The first-mentioned emits a green light at the attachment of each scale. In the second the feet are light givers and emit a blue light. In the third the light blazes on the back at the tenth joint alone. The last is a worm of fire, the strange, little understood light blazing over its entire surface, a vivid blue.

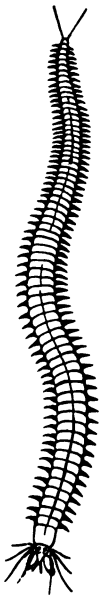


FIG. 76. — A marine worm (*Nereis*).

I was once sitting on the shore of Avalon Bay in southern California when, in the darkest corner in the shadow of a high cliff, I saw, two hundred feet away, what appeared like candle lights floating upon the surface. Rowing a boat to the lights, I found that each one came from a spot of phosphorescence floating on the

surface. When it moved, as it often did, phosphorescence streamed away in its wake. When taken in my hand the latter became bathed with the light which ran from the invisible animal. I succeeded in capturing one entire light, but could not make out the animal. Soon I noticed lights upon the bottom in water five feet deep. They appeared to be as large as saucers, but grew rapidly in size until they were as large as dinner plates, then the yellow light gradually diminished until it was not larger than a hazelnut, and came wriggling upward in a zigzag of fire, finally reaching the surface and resting, as one of the peculiar lights I had seen so far away. I captured several, and in the morning found that my light giver was a minute sea worm not half an inch in length. When discovered, the little animal was leaving its burrow or cave in the sand for a nightly swim at the surface.

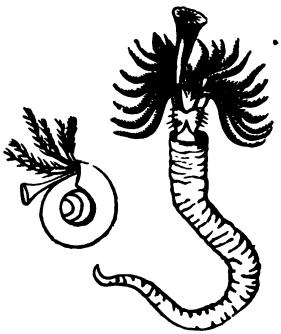


FIG. 77. — A tube-secreting worm.

Many of the most beautiful of the marine worms are cell builders (Fig. 77). In some the worms secrete a tube of carbonate of lime. In others the den is made of bits of sand. I found on the Florida Reef many remarkable examples of the latter. The nest or tube was built among the seaweed, several inches above the bottom, and would naturally be a conspicuous object; but here the intelligence of the little creature is seen, for it covers the outside of the column with the plates of a lime-secreting seaweed, which look like shingles, and mounts upon the upper portion

of the column a green bit of seaweed. This is glued to the tube and so arranged that it falls over the entrance and closes it, thus serving the purpose of a door and making the tube mimic a bit of sea grass. The worm lifts the grass door when it comes out.

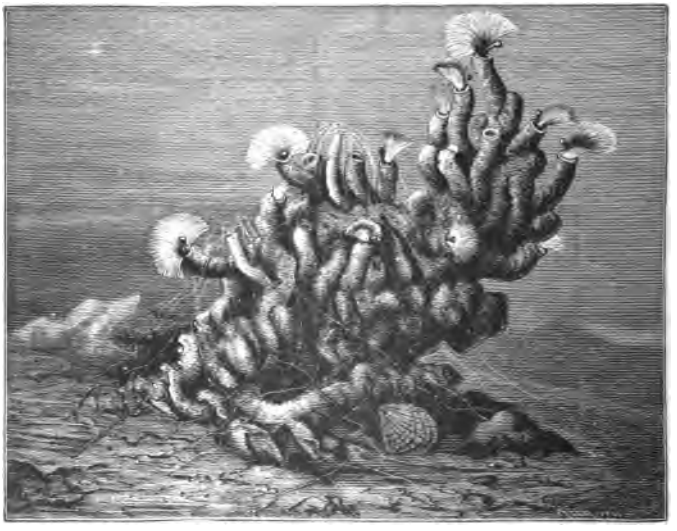


FIG. 78. — A group of tube-secreting worms (*Serpulæ*).

One of the most familiar forms is Serpula (Fig. 78), whose tubes wind in and out in every direction. No garden of pansies gives a greater variety of tints than did a mass of these radiant creatures that I found on a floating spar in the Pacific at Avalon Bay. But touch these "flowers" or jar them and they disappear like magic, leaving a hole closed by a little door, which is formed by a part of the worm that thus defies all intruders.

XI. THE TWO-VALVED SHELLS

THE beautiful objects which we know as shells, and which form ornaments in many a home far distant from the sea, are the coverings of a group of animals called mollusks. They are found in all seas, many upon land, and in fresh-water streams, and are among the most attractive of all natural objects, so much so that many per-

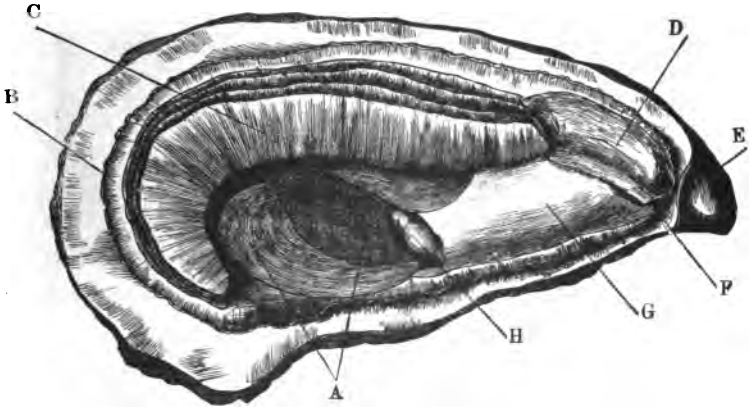


FIG. 79. — The oyster: *A*, muscle; *B*, mantle; *C*, gills; *D*, labial palpi; *E*, hinge; *F*, mouth; *G*, liver and stomach; *H*, heart.

sons devote their entire lives to their collection, and many others much time to the study of their habits. It is rare to find a new shell, so well have these shell hunters searched the waters of the world. Such collections, especially if complete, are very valuable, and many of the great museums have paid thousands of dollars for them

The mollusks or shells present a striking contrast to the worms. They have no joints, are soft, seemingly without form, and are very helpless creatures. The body is enveloped in a muscular coat or mantle, as shown in the oyster (Fig. 79). They have a nervous system, and a heart (*H*) which pumps colorless blood. Some have a foot for locomotion and eyes more or less well developed. The oyster represents a large group which have two shells,

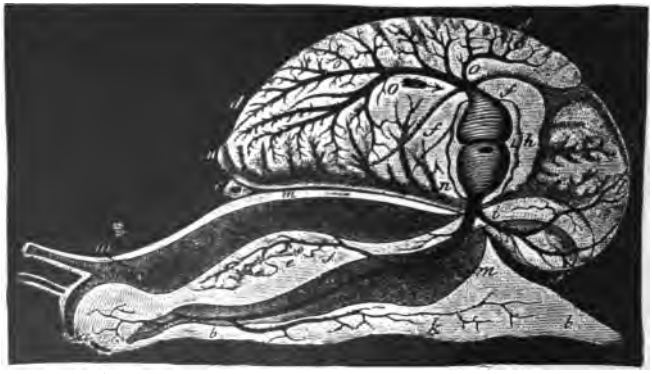


FIG. 80. — Anatomy of snail: *a*, mouth; *b*, foot; *c*, anus; *d*, lung; *e*, stomach; *f*, intestine; *g*, liver; *h*, heart; *i*, aorta; *j*, gastric artery; *k*, foot artery; *o*, lung and heart artery.

called bivalves. In Figure 80 we see the animal portion of the common snail, which illustrates another group with but one shell. These are called univalves. To the bivalves belong the shells best known, the oysters, clams, scallops, pectens, pearl oyster, razor shell, and many others, of which the oyster is the most familiar. The mantle, the soft, delicate lining, is the shell maker, and not only forms it, but repairs damages to it, piling up layer after layer of pearly matter called nacre. As there is a

mantle on each side, two valves are secreted. The sharp portion of the oyster is called the beak. Here the growth of the shell begins, and here are the marvelous valves which fit with such accuracy. These complicated parts are easily seen in the clam (Fig. 81). The hinge is joined by teeth (*c*, *d*, *d*,) which fit into cavities on the opposite valve, while the valves are held together by a perfect hinge, a horny ligament (*h*) that tends to open the shell or throw the valves apart.

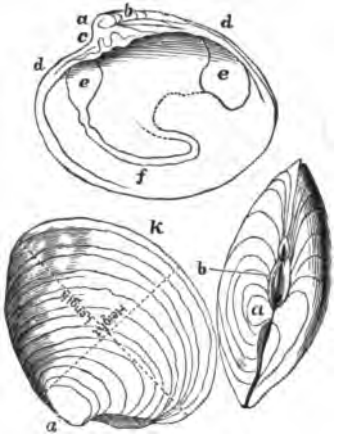


FIG. 81. — Bivalve shells: *a*, beak; *k*, base; *b*, *b*, hinges; *c*, *d*, *d*, teeth; *n*, ligament; *e*, *e*, adductor muscles; *l*, lines of growth; *f*, pallial line.

In the interior of all shells are seen certain scars; in others a purple mark. These marks (*e*, *e*,) indicate the location of a strong muscle by which the clam or oyster closes its shells and keeps them closed with such rigidity. In opening oysters the man severs this muscle and the shell opens, forced apart by its ligament. This explains why most shells found on the beach are wide open. The curious columnar objects in rows are the gills or breathing organs of the oyster, and are

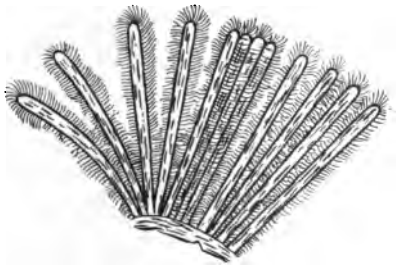


FIG. 82. — Cilia or oars of a mollusk, highly magnified.

covered with little oars (Fig. 82), or cilia, which move to and fro, continually sweeping the currents of water along, bearing oxygen and food. The former is taken up by the gills to purify the blood, and the latter is swept into the mouth located near the lungs.

There is great variety in the hearts of shells. In the oyster (Fig. 79) it is composed of one auricle and one ventricle; but in other shells the heart may be three-chambered, or there may be two distinct hearts, each having two chambers. The eyes of the shells are very minute and are situated along the mantle. Those of the pecten are very beautiful and are distinctly visible, resembling gems or emeralds.

The clams (Fig. 83) differ from the oysters in having a pronounced foot (*f*) which protrudes from the large end of the shell; and with it the animal digs its burrow. It

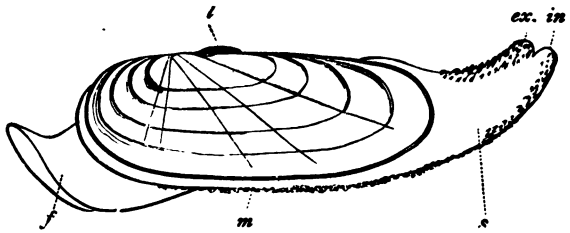


FIG. 83. — A clam: *f*, foot; *m*, mantle; *s*, siphon.

also hears indirectly by its foot, as its ears are in this organ, little transparent sacs containing a clear fluid in which floats a glassy globule. The clam also has a siphon (*s*), which in the common clam is very long. It has a black head or tip and the clam may rest some distance down in its hole and take in water through its siphon,

which is double-barreled. One opening (*in.*) receives water containing food and oxygen; the other (*ex.*) expels the water. In strolling along the sands at low tide one often sees a spurt of water shoot out of a hole, and may assume that a clam has been alarmed and has retracted its siphon so suddenly that it has shot a stream of water above the surface. The shells increase by eggs, the oyster depositing a vast number, which at first are curious little free-swimming objects (Fig. 84) paddling by the aid of cilia or whips, but soon attaching themselves to the bottom and taking the oyster form.

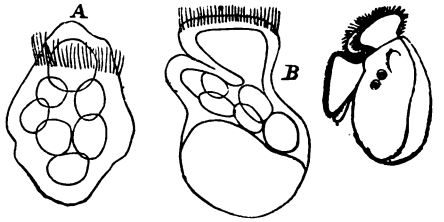


FIG. 84. — Free-swimming young of a bivalve.

The oyster is perhaps the most valuable bivalve to man, being a favorite article of food, for which $1,500,000 is paid annually in New York alone. Thousands of men find employment collecting them in various parts of the world. In this country the most valuable oyster beds are in the vicinity of New York, at the mouth of the Shrewsbury River, in the Chesapeake Bay, and at various points alongshore to Florida, where there are large banks at the mouths of the rivers. In watching the excavation of a cellar at the town of Mayport at the mouth of the St. John River I saw oyster shells thrown up as deep as the men went. The town is built on an ancient oyster bed. Among the old shells numerous pieces of pottery have been found, showing that the early natives frequented the spot. The living oyster bed here to-day is some distance out in the stream.

When sailing up a small river in Maine some years ago, I found, about ten miles from its mouth, a mound of oyster shells thirty or forty feet high. The river appeared to have cut the bed in two, and out of the top of the mound, which was of solid shells, grew a tree which must have been a century old. I believe there are no oysters on the Maine coast to-day, and the great pile was accumulated ages ago when Maine had oyster beds and the Indians

FIG. 85. — Pearl oysters.

carried the oysters ten miles up the river to this spot which must have been the site of an ancient Indian town or city. The pearl oyster is another valuable shell (Fig. 85). It is common in warmer waters. Near La Paz in the Gulf of California is a famous fishery, which is owned by the government and farmed out. In Ceylon it is estimated that 17,000,000 oysters are destroyed to obtain $80,000 worth of pearls. The shells are also very valua-

ble, being made into buttons and various other objects. Liverpool is the great receiving port for these, and many tons are used annually. In diving for pearls the Ceylonese, who are able to remain beneath the water several minutes, place as many shells as possible in a basket and then ascend, leaving the crew to haul the basket up. In Lower California many divers of to-day go down in armor.

Pearls are generally valued according to their symmetry and color. Some are perfect, and when of large size bring vast sums. One of the shahs of Persia owned a necklace in which the pearls were perfect and as large as hazelnuts. The pearl is the result of the oyster's attempts to protect itself from injury. If we should take one of these beautiful pearl oysters and with a gimlet bore a hole through the shell from the outside and replace it in the water, we should find, months after, if the oyster was examined, that it had, by using its mantle, secreted a large amount of pearly nacre over the wound, not only filling up the hole, but heaping the pearly secretion over it until a projection a quarter of an inch high was the result, resembling a pearl attached to the shell. This is the way imperfect pearls are formed; they are the attempts on the part of the oyster to prevent injury to itself. Occasionally some foreign body, like a grain of sand, will enter the shell. Its sharp edges will cut the soft flesh of the delicate creature, which immediately covers it with pearly nacre. The larger it grows the more the oyster notices it among its folds, and the more it instinctively covers it with pearl. In this way the pearls grow.

The seed pearls are those in which some impurity has

been covered but a few times, while the very large pearls are those which have been bathed in nacre time and again. If a large pearl is cut in halves, the various layers can be counted, the sections recalling the interior of an onion. The skillful native fakirs of the East take advantage of this industry of the pearl oyster to introduce metal beads and figures of the Buddha into shells, which are then marked. The objects finally become covered, when they are removed from the shells and sold to the unsuspecting natives as "miracles."

One of the interesting shells of the seashore is the Pinna. I have found the shores of the outside islands of Texas scattered with them. They are also called fan shells, and are attached to the bottom by a peculiar cable, or byssus, formed of a silklike substance which has been woven. Gloves and hose of pinna silk may be seen in the British Museum.

The pectens are common forms famous for the beautiful gemlike eyes seen along the edge of their mantles. I once kept a number of these shells in an aquarium, and they were a source of much amusement, from their habit of dancing (Fig. 86). Generally they lay in the sand in the bottom of the tank with their valves open an inch or more, their bright eyes gleaming. Without any warning, one would open and close its valves with great rapidity, which would cause the shell to take convulsive and bounding hops. Then another shell would

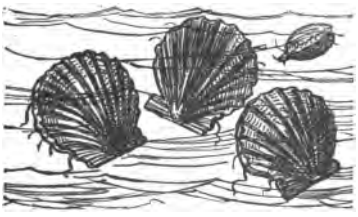


FIG. 86. — Pectens swimming.

follow, and soon all the pectens were leaping up and down in a most extraordinary dance. The pecten changes its position or travels, not by pushing itself along, but by a sudden and spasmodic hop, clearing a foot or more.

The locomotion of shells itself is a fascinating subject. An interesting instance is observed in the common mussel. This shell has a remarkable foot, a pointed, fleshy organ which can be protruded. With this organ the mussel bores holes in the sand, jerks itself along, or clears the surface with a bound. But its most remarkable service is in aiding the mussel to climb. In the foot, near its base, is a gland which secretes a peculiar substance, which when exposed to the water hardens and resembles silk. The resemblance is so perfect that the "silk" has been woven into various articles, and an attempt was made in France to raise mussels for this purpose. When the animal desires to climb, it reaches out its foot as high as it can (Fig. 87), and presses it upon the pile or rock, whereupon a delicate cord, one of the cables of its byssus, is seen. Again the foot is extended, again a cable is attached, the entire operation calling to mind the action of a spider. Each step raises the mussel a little higher, and as it moves on, the cables that would hold it back are broken off, and the mussel at length reaches the position it desires.

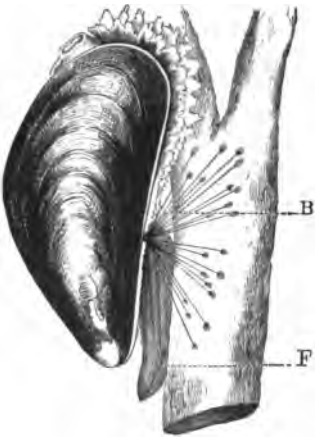


FIG. 87. — Mussel climbing: *B*, cables; *F*, foot.

The fresh-water mussels found in the Ohio and other rivers and streams are pearl producers. Very valuable gems have been taken from them in various states, and the fresh-water pearl fishery of the United States is of considerable importance. A fresh-water pearl found in New Jersey was valued at $2000, and one taken from a stream in Scotland brought $50,000.

The vast number of shells and the varieties of each kind can hardly be realized by those who have not examined a well-equipped collection. Over four thousand species of the mussel are known, and hundreds of species of almost every shell exist in various streams and seas. The shells range from minute specimens hardly visible to giants weighing several hundred pounds, one of the latter being the huge clam, Tridacna (Fig. 88), found in the equatorial Pacific. There are several species, and in the largest each valve weighs about two hundred and fifty pounds. The animal itself weighs thirty pounds, and affords a meal to forty or fifty men. The shell, by means of its foot, buries itself in the soft rock of the regions in which it lives. With its valves partly open it resembles a huge sea anemone; but it closes them at the slightest alarm. Large fishes, and even natives, it is said, have been

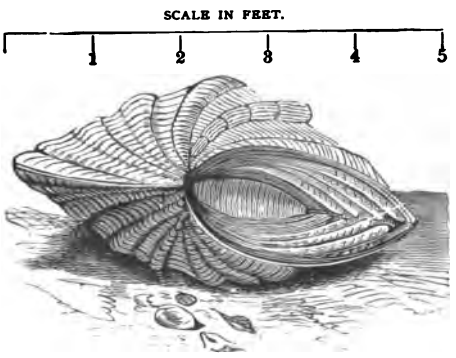


FIG. 88. — Giant clam.

trapped by this giant, whose jawlike valves, with three huge teeth, grip the fin of a fish or the foot of an unfortunate wader with a vicelike grasp. The byssus or anchor of this huge shell is so thick and tenacious that it is severed only with great difficulty and labor. The shells are valuable as ornaments, large numbers being sent to various countries for this purpose. The giant never moves, and in this respect is a sharp contrast to the little donax, so common on our various shores and in France, which leaps along the muddy flats by convulsive movements of its fleshy foot.

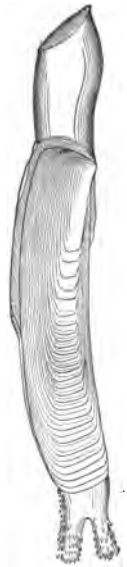


FIG. 89.—Razor clam.

The common razor clam, of which sixty or more species are known, by means of its foot (Fig. 89) digs a deep burrow which is filled with water even at low tide. The shell is often found at the entrance, but at the slightest alarm it dashes deep down into its den, to be caught only by persistent digging.

The odd shapes assumed by many bivalves is well illustrated in the hammer oyster (Fig. 90) and the pholas. The latter illustrates the power of the most insignificant animals, as by means of its foot this little shell burrows into the hardest granite. It is invariably found there and imprisoned; for when it reaches the interior of a stone, it grows and enlarges, leaving but a small opening for the siphons. It is supposed by some that the pholas possesses some secretions by which it dissolves the stone, and by others that it wears away the rock by using its shell as a file. In any event the shell is known to contain aragonite,

a very hard substance. In the pillar of the temple of Serapis, Italy, the holes made by this shell are seen.

Perhaps the most remarkable feature of the pholas is its power as a light giver. It emits a delicate blue light, dead

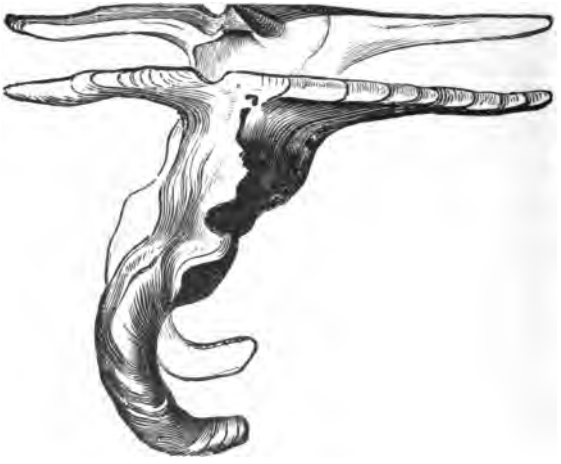


FIG. 90. — Hammer oyster.

FIG. 91. — Teredo, a boring shell.

or alive. One placed in a glass of milk has been used as a lamp, illuminating the faces near it. Another placed in honey retained its phosphorescence for over a year. The little pholas is found all over the world, more than eighty different species being known.

The teredo or shipworm (Fig. 91) is called a worm because it secretes a limy shell, but it is really a bivalve shell open at both ends, a shell which with one exception causes more destruction than all other marine animals combined. Instinctively it bores into wood, forming an irregular tunnel and lining it with a

delicate coating of carbonate of lime. Some years ago I visited on the outer Florida Reef, an old wreck which was newly buried in the sand and partly exposed at low tide. The timbers of the vessel looked strong and able to stand many a storm, yet with a blow of my hand I broke through the planking. The interior was completely honeycombed by the teredo, so that it was a maze of tubes. At this place the life of a pile of yellow pine was a year and a half; in other words, after being exposed to the teredo for this length of time, it was useless. On the

FIG. 92. — Mactra: *a*, foot; *b*, *c*, siphons.

Pacific, at Avalon Bay, the piles last about two years, being rapidly destroyed, even though soaked in various poisonous fluids and coated with tar. Many thousands of dollars have been expended in experiments with devices to outwit the teredo, but without avail, and they are the greatest menace to navigation and piers to-day, making their way into hulls, despite the copper sheathing. In the mud banks of the waters of Sumatra, teredos are found which attain a length of six feet, with tubes four inches in diameter.

The shells are famous for their beauty, the polished valves and their marvelous tints presenting attractive combinations. The common mactra (Fig. 92), the cockle (Fig. 93) with its deep radiations, the gorgeous pectens of the South, the splendid pearl-bearing shells, all tell a wonderful story of the resources of nature, and emphasize the fact that the smallest and most inconspicuous animals vie with the larger forms in beauty of shape and color.

FIG. 93. — Cockle.

XII. THE UNIVALVES

THE shells which have been noticed in the preceding chapter belonged literally to the stay-at-homes of the family. They rarely wander far, and many, as we have seen, never leave the place which the young shell first

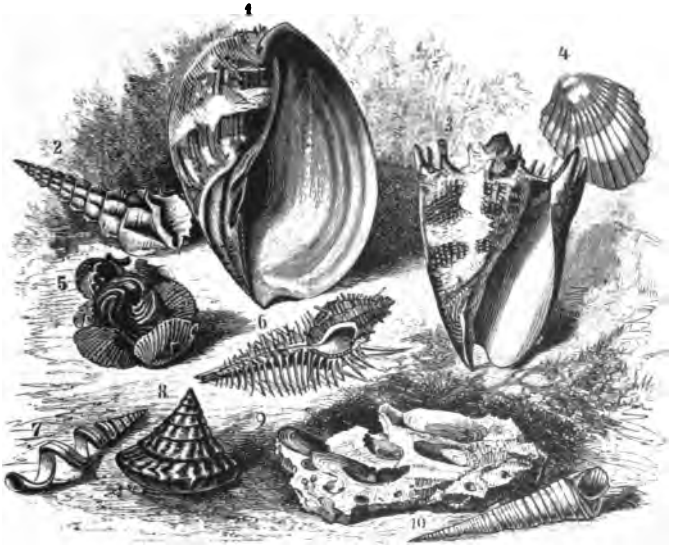


FIG. 94. — Group of shells: 1, Cymbium; 2, Cerithium; 3, Voluta; 4, Cardium; 5, Phorus; 6, Murex; 7, Vermetus; 8, Trochus; 9, Pholas; 10, Turritella.

selected as its home. What are known as the univalves, the mollusks with one shell, or perhaps no shell at all, are the reverse of this, being in many instances travelers, wandering here and there. This suggests that they have

more highly organized locomotive organs. Those shown on the upper part of Figure 94 are univalves, and if we make a section of a univalve (Fig. 95), we see that the shell is much more complicated than in the previous forms. The univalve has a shell-secreting mantle and organs resembling those of the bivalves, only differently placed. This marvelous mantle performs some singular feats, judging from the spines found on many shells. To make these, the mantle must have been thrown outward and upward, forming a tube in which the spine was secreted.

FIG. 95. — Section of a univalve.

In the univalves a distinct head is seen (Fig. 98) with tentacles and prominent eyes. The foot is now elaborated into a huge sucking, clinging, disklike organ. In the whelk it is as long as the shell, the latter being perched high above it, presenting a remarkable spectacle as it moves along the sandy floor of the ocean. On the head are two tentacles, feelers or sense organs, and sometimes the eyes are mounted on tall stalks, that the shell may have a wide range of vision. A siphon, such as we have seen in the clam, is present and extended upward and forward. It protrudes from a canal formed in the shell for the purpose, and is often very long. If the whelk (Fig. 99) is disturbed, it suddenly withdraws its body, including the enormous colored foot; and if the

shell is picked up, the entrance is found securely closed by a horny door called the operculum, which is attached to the foot (Fig. 99). This door takes many shapes. In the beautiful conch it is saber-shaped, and is used to dig into the sand, or, as a lever, to force the conch along by a series of jerks. In other shells it is apparently made of porcelain, hard and highly polished. It is well known as the "eye stone" of popular fancy.

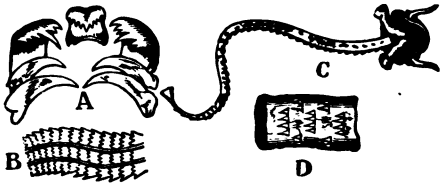


FIG. 96. — Tongue and teeth of a univalve: *A*, portion of tongue of Velutina; *B*, portion of tongue of whelk; *C*, head and tongue of limpet; *D*, portion of same enlarged.

Many of the univalves are flesh eaters, preying upon others of their kind. They have a remarkable tongue (Fig. 96) for the purpose, in fact, the teeth are upon the tongue in sawlike rows. The tongue, which is called the lingual ribbon, is ribbon shaped, long and slender, and is really a soft, pliable saw with which the animal bores into the hardest shells of the helpless clams. In strolling alongshore a large majority of the "dead" clam shells found bleaching in the sun, where they have been washed by the sea, will be seen to contain a circular hole of perfect symmetry (Fig. 97). This has been made by the boring, sawlike tongue of a univalve, which, after gaining an entrance into the tightly locked shell, deliberately sucked it out.

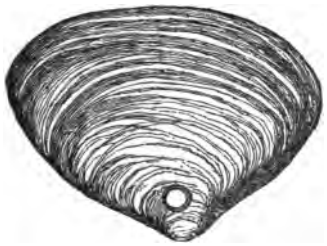


FIG. 97. — Clam shell bored by a univalve.

It is interesting to note the location of this hole, which is invariably over the softest and plumpest part of the victim, near the lungs, showing that the cannibalistic univalve is very clever in its mode of attack.

While the oyster deposits vast quantities of eggs, which float out into the water to be destroyed by other animals, many of the univalves protect their eggs in remarkable cases. I have often found on the Florida Reef strings (Fig. 98) of singular objects which resembled sections of a yellowish cylinder connected by a little cord. Each section is an egg case, or capsule, and contains many

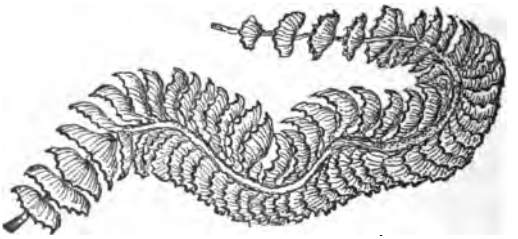


FIG. 98. — Egg case of a conch.

shells, the entire chain being two or three feet in length. This becomes tangled in the coral or seaweed, and holds the young shells, all of which escape through a little door in each section.

Other shells, as the whelk (Fig. 99), deposit their egg cases in heaps or mounds. They are soft and spongelike, and are often mistaken for sponges when divested of their shells and cast ashore. Perhaps the best-known egg case is that of the common Natica, which forms a singular object called the "sand collar" (Fig. 100). The animal molds this collar out of fine sand with its foot, and

deposits its eggs in the interior, all being cemented or

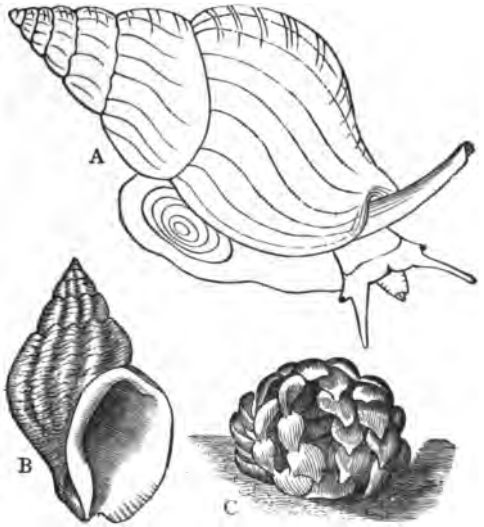


FIG. 99. — The whelk: *A*, living shell; *B*, empty shell; *C*, egg case.

glued together in a solid mass. We shall find that certain birds deposit their eggs in the nests of others, so saving the wearying process of hatching. A certain shell, called Nassa, has a similar habit. At times it deposits its eggs on the collar nest of the Natica.

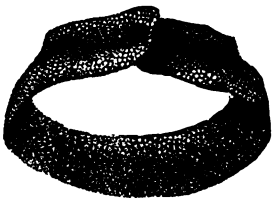


FIG. 100. — Egg case of the Natica.

Among the myriads of shells which we may select to illustrate the various interesting types, shapes, and kinds, are the Chitons (Fig. 101). Their shells are made up of many plates resembling the plates

of a hawkbill turtle. Many live in holes in the rocks,

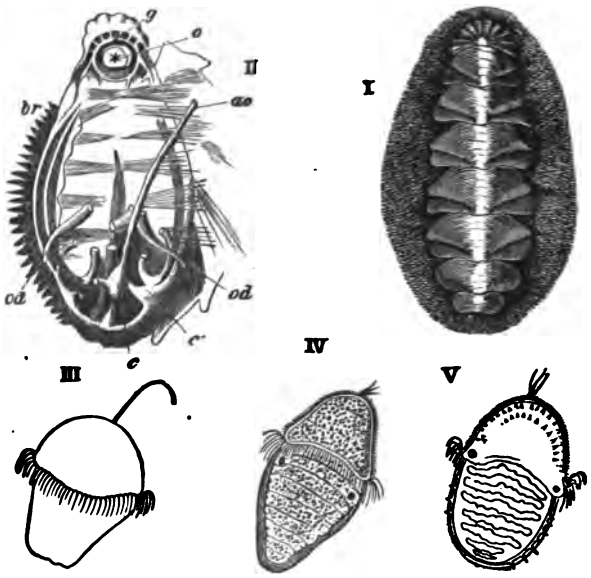


FIG. 101. — The Chiton and its free-swimming young. I. Adult, showing plates. II. Chiton dissected: *o*, mouth; *g*, nervous ring; *ao*, great artery from the heart, aorta; *c*, ventricle; *c'*, an auricle; *br*, left branchiæ; *od*, oviducts. III, IV, V. Development of free-swimming young.

and all have a very large, sucking, disklike foot which clings to the rocks with great tenacity. Resembling them somewhat are the limpets. These are interesting and beautiful shells, especially when polished, forming attractive domes marvelously tinted and colored. Some are called keyhole limpets (Fig. 102), from the fact that they have a keyhole-like opening in the top. They range in size from very minute forms to giants a foot in length.

FIG. 102. — Keyhole limpet.

Among the most beautiful of all shells, and at the same time the most common in tropic and semitropic seas, are the abalones. They are also called ear shells. They have an enormous foot that covers the entire lower surface, being a remarkably powerful organ. Instances have been known where Chinese abalone hunters have tried to pry off the shell from a rock with their hands, and have had their fingers caught and held as though by a vice.

The Haliotis is very common on the shores of the southern Californian islands. In some localities every rock is covered with them, and in places where the black abalone is common, I have found them piled one upon the other. There are two hundred species living. Every tint, color, or tone known in the scale of color, or its combinations, is flashed from these marvelous shells, which, if rare, would be counted among the most beautiful of all natural productions. On the Californian coast they are collected in large numbers, and when polished are converted into buttons and a thousand and one other objects. The meat, which is of excellent quality, is sold in large quantities to the Chinese. Thousands of the shells are bought by tourists, the outside being richly polished. From the ancient graves or Indian mounds of the Californian islands I have taken quantities, especially the large kind known as the red abalone, showing that they were used by the ancient inhabitants. In all of these islands heaps and piles of abalones are found far from the water. By stopping up the holes in the shell with asphaltum, which drifts ashore here, the natives had an excellent dish, or bailer. They cut the shell into earrings and ornaments of many kinds, and most of their fishhooks were evolved

from this beautiful shell, which also supplied a large proportion of their food.

On the Florida Reef the great conchs (Fig. 103) are very common. They live on the sandy floor of the lagoons, hitching themselves slowly along by their long-pointed, saberlike operculums. This is the conch of commerce,

FIG. 103. — Great conch (*Strombus*).

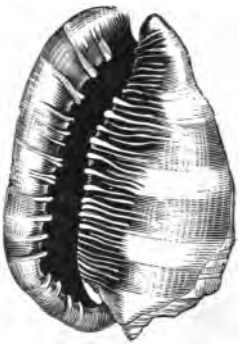


FIG. 104. — Queen conch (*Cassis*).

in which appears the most delicate of all pink colors, and which is the source of the rare pink pearls. In the same locality, but in deeper water, is found the Queen conch (Fig. 104), which is cut into medallions and cameos. The beautiful Cypræa (Fig. 105), of which many varieties are known, are called micramocks in Florida, and cowries elsewhere. Their luster and natural polish often excite wonder, for they commonly live concealed in the rough portions of dead coral branches, where they would easily become scratched. The cowry, however, is protected by a remarkable mantle

FIG. 105. — Cypræa.

which covers the entire shell, thus keeping its pianolike surface as smooth as a mirror. Many cowries are beautifully striped; some are spotted with dark spots on a white background; some are yellow; others are red or old gold, every tint and color seemingly being employed by nature in painting these gems of the sea. Few other shells have been so universally esteemed by all nations. Among certain African tribes they are used as money, and not many years ago collections of cowries were made with all the ardor that actuated the tulip collectors, thousands of dollars being paid for single shells, as the orange cowry.

The cone shells (Fig. 106) represent a beautiful group, spotted like leopards, striped like the tiger, black, red, yellow.

FIG. 106. — Cone shell (*Conus*).

FIG. 107. — Augur shell (*Terebra*).

FIG. 108. — Spindle shell (*Fusus*).

Some shells are very pointed, like the augur shell (Fig. 107). Some have an extraordinarily long projection for the siphon, as the spindle shell (Fig. 108). In some the opening is very small, as the cone shells, while in others it is immense, and protected by a large, doorlike oper-

culum. The Bulimas is a famous nest builder. Bulla is interesting from the lightness and delicacy of the shell and its rich neutral browns.

Among the very familiar shells are the land snails (Fig. 109), common in every garden and raised and sold in France and Italy as table delicacies. Closely allied to them are the slugs, which bear upon their backs, beneath the skin, a delicate, scale-like shell. On the island of San Clemente, fifty miles off the coast of California, I found an extensive sandy plain which was so thickly strewn with the white, bleached snail shells that I could hardly step without crushing several. The verdure had died, and the snails were doubtless killed by the direct rays of the sun.

FIG. 109. — A snail crawling.

These interesting animals are called pulmonates because they breathe air directly.

The slugs (Fig. 110) have many peculiar characteristics. If the long tentacles on the short eye stalk are destroyed, the snail will reproduce them. In winter the snails descend into the ground, or hide themselves away, literally sealing themselves in their shells by closing the door firmly, and there hibernate until spring, neither eating nor drinking, and hardly breathing during this time; if placed in a cold storage box, they will remain several years in this state.

Some of the snails of Africa are six inches across, and the eggs are an inch in length. Semper found a little snail in the Philippines, which when caught by the foot or "tail" throws it off as a lizard jerks off its tail. This is not a great hardship, as the tail is soon renewed. In a collection of shells which came from France some years

FIG. 110. — Slugs and snails.

ago I found several snails of different colors which were joined one to the other. The collector had cut the top from an empty brown snail and placed a living snail with a yellow shell upon it, tying the two together. The snail, supposing that its shell had been broken, immediately began to repair the wound, and closed up the breach with its shell-secreting mantle, so that the two shells became one.

In floating on the borders of the Sargasso Sea, the vast sea of weeds in the South Atlantic, I found numbers of a beautiful sea slug (Fig. 111) which so resembled the weeds in shape and color, a rich olive green, that it was almost impossible to distinguish it, except when very close to the surface. They have attractive names, as Doris, Tritonia, Æolis, and Aplysia, and are among the wonders of the great belts of kelp which surround the continent. I once found a slug at Santa Catalina which was a vivid, almost iridescent purple; another was yellow; but the most interesting was Aplysia, a giant two feet long, which I kept in an aquarium. It weighed nearly eight pounds, could lengthen itself out to a distance of nearly three feet, or contract into a dark, olive-hued ball, scarcely six inches across. It took sea lettuce from my hand, eating with avidity, and when disturbed emitted a purple ink which filled the water and hid the monster "sea hare" from view. It laid its eggs on the sides of the tank in long chains, but if not well fed, exhibited a decided cannibalistic tendency, devouring its own progeny. This animal had an enormous foot by which it crept rapidly along, and it invariably protected itself by imitating the color of the bottom upon which it rested.

FIG. 111.—A sea slug (*Dendronotus*).

One of the most interesting slugs is the Onchidium (Fig. 112). According to the naturalist Semper, it has upon its back numerous eyes, which enable it to see from above. It is a mud-loving form, common in our

new provinces, the Philippines, where the heat is intense and the water warm. One of the land slugs, Limax noctiluca, emits light; and the eggs of another, Arion, have been noticed to be luminous for nearly two weeks after being deposited.

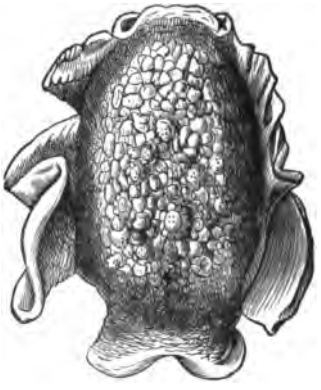


FIG. 112. — *Onchidium*, a sea slug with eyes on its back.

Nearly all these shells are slow-moving animals, but there are others, the pteropods (Fig. 113), which are swimmers. The veritable fairy craft of the sea, they are

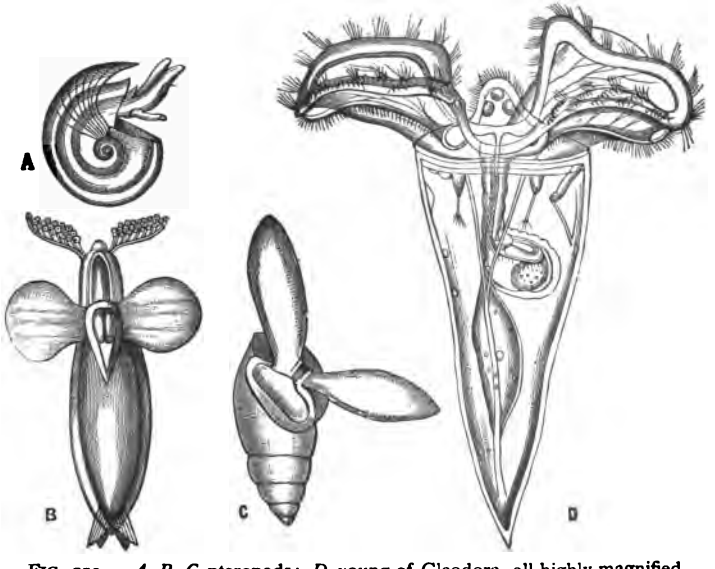


FIG. 113. — *A*, *B*, *C*, pteropods; *D*, young of Cleodora, all highly magnified.

housed in shells of dainty structure and moving by singular winglike fins, which give them the name of ocean butterflies. They have the property of phosphorescence to a remarkable degree. Cleodora (Fig. 113, *D*) emits a soft light which gleams through the delicate shell like a light in a lantern. In swimming it moves its fins up and down very much like a butterfly, so that they touch at the top. As delicate and dainty as this little creature is, it has a marvelous arrangement for seizing prey, each tentacle having about three thousand transparent cylinders, each of which contains twenty stalked suckers. As there are six tentacles on each sucker, Cleodora can grasp its prey with three hundred thousand hands. Equally dainty in its way is the sea snail, Ianthina, a violet shell of great delicacy, whose foot develops a raft which resembles a mass of soap bubbles, so the violet snail floats upon the surface of tropical and semi-tropical seas. I have seen the shores of the keys of the Florida Reef lined with an undulating ribbon of these shells after a storm. When touched they emit a rich violet ink which lasts a long time as a stain. A small species of Ianthina is found in the winter on the southern Californian shores, and beneath the attractive float will be found the eggs.

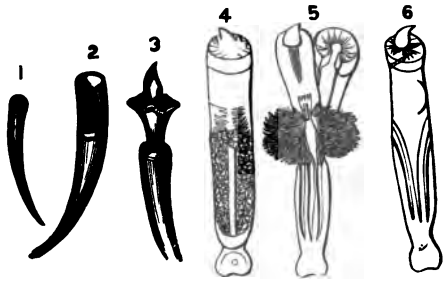


FIG. 114. — 1, *Dentalium entalis*, natural size; 2, shell magnified, and broken to show animal within; 3, animal projecting from the shell; 4, animal from below, magnified; 6, same from above; 5, same, showing internal structure.

XIII. THE CUTTLEFISHES

In the great libraries of the country will be found books dating back to the last two centuries, many of which contain cuts and descriptions of frightful animals resembling huge spiders, called krakens, or devilfishes. They are represented climbing over ships, and hauling them down. One is described as so huge that the crew of a vessel landed upon it, not discovering that it was not an island until they had built a fire, when the supposed island, really a kraken, sank beneath them. These are tales of romancers, but it is interesting to know that they are based upon a slight foundation of fact. Devilfishes have been discovered in various seas, which weighed several hundred pounds, and whose length ranged from fifty to seventy or more feet. Such an animal is the giant squid (Fig. 115), which is a very timid animal, and though it might overturn a small boat, it is not likely to make the attempt.

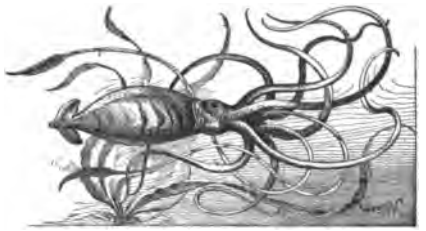


FIG. 115.—A giant squid, fifty feet long.

These animals are called cephalopods because their feet are attached to the head; in other words, they are head-footed. The typical squid or cuttlefish has a barrel-shaped body, and a tail resembling an arrowhead. Its head is

separated from the body by a seeming neck, and is provided with two immense eyes (Fig. 116). Projecting forward are two long, slender arms, and eight shorter ones, which in the giant squid are from six to ten feet in length. These are armed with peculiar suckers (Fig. 117), each of which is extremely powerful. In a specimen six feet long, which I kept for an hour

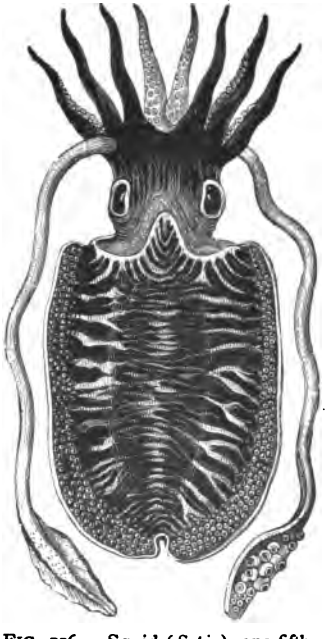


FIG. 116. — Squid (*Sepia*), one fifth natural size.

FIG. 117. — Suckers of a squid.

alive in a large tank, some idea of the strength of a squid could be obtained. It fastened its eight arms to the tank, and with all the force I could bring to bear I was unable to tear them off. Besides the eight short arms there are two long ones.

In a specimen of the giant squid which I handled and measured, the long arms were about thirty feet in length.

The ends were enlarged with paddlelike organs, and bore a group of suckers. The object of the long arms is to serve as graspers. They are kept near the body, coiled up, and can be shot out with remarkable velocity, grasping a fish

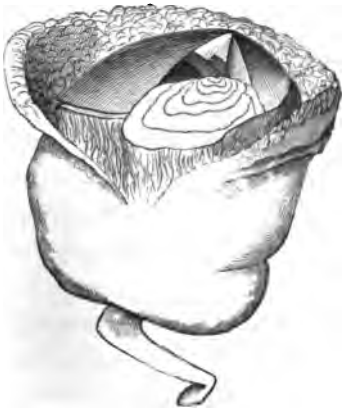


FIG. 118. — Beak or bill of a squid.

like two hands with gigantic arms. They haul the prey to the short arms, when hundreds of sucking disks hold the victim that is now pressed to the remarkable mouth. This lies between the base of the arms, and in color and appearance is almost exactly like the beak of a parrot, with the exception that the under bill fits over the upper (Fig. 118). These bills almost invariably nip the struggling fish over the vertebra or back bone, severing it at once, and ending the struggle. The tongue of the squid is a ribbon with teeth upon it. Such an armament alone is sufficient to attract attention to the animal, but

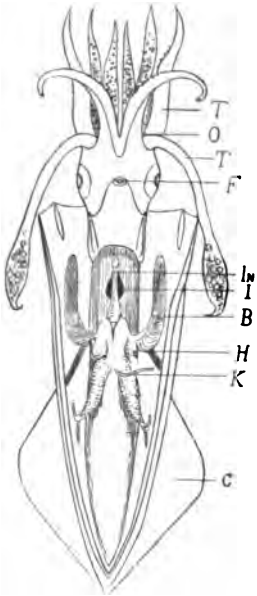


FIG. 119. — Showing parts of a squid: T, tentacles; *O*, mouth; *F*, siphon; *In*, intestine; *I*, ink bag; *B*, gills; *H*, heart; *K*, blood vessel; *C*, lobes of tail.

it has still another feature which adds to its interest as a weird and disagreeable creature. The squid has a siphon which terminates in a tube, opening beneath the head. Into this an ink bag opens (Fig. 119). In swimming, the squid rarely if ever rests upon the bottom, but takes in water around the edge of the mantle and ejects it with more or less force from the siphon, and thus the squid is driven along, tail foremost. When alarmed its movements are very rapid. If in danger, the squid pours an inky secretion, which is the sepia of commerce, into the siphon, and the secretion is swept out into the water in a cloud which spreads rapidly, to the confusion of any following enemy.

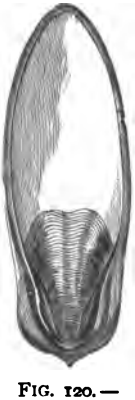


FIG. 120.— Cuttlefish bone.

The squid has a shell, but it is very small, and internal. It is called the pen, and that of some species is the cuttlefish bone of commerce (Fig. 120). In specimens six or seven feet long, taken at Santa Catalina, California, the pen was fifteen inches long and glasslike — a perfect pen in shape. Such is this peculiar creature, and if we add that it can change its color from very dark brown to almost white, adapting it to the color of the bottom over which it rests, we can form some idea of one of the strangest of all animals. They deposit eggs in clusters.

FIG. 121. — Eggs of the squid.

The squids range in size from gigantic specimens seventy or more feet in length to the minute Cranchia, which is luminous at times. Some have no tails, some only the suggestion of a tail, some have very pointed ones, some very broad ones. In specimens of the little Cranchia which I observed the head was very small and the body long in proportion. One form appears to have side winglike fins. The large squids live in the deep sea, and most of the specimens known have been taken from the deep fjords of Newfoundland, which appears to be a favorite locality for them. They doubtless live everywhere in the deep seas, as they are almost invariably found in the stomach of the sperm whale, evidently constituting a favorite food of this giant-toothed whale.

The squids live mainly upon fishes, and are very skillful in taking them, poising like a cat, near the bottom, creeping upon a school of sardines, — all the time simulating the color of the bottom, and almost invisible but for their large, dark eyes standing out, — then suddenly darting tail first into the school, flinging the long arms at the flying fishes, and almost always catching one, which is dragged up to the parrotlike bill and dismembered. In the six and seven foot squids taken at Santa Catalina the stomachs were filled with seaweed, showing that at least some of these animals are vegetarians.

On all tropical shores is found a beautiful coiled shell, the Spirula, with little pearly septa dividing it. I have seen a windrow of these shells a mile long, but never found the animal and shell together, so easily are they disconnected. It is the smallest and the most beautiful of all the cephalopods.

I could release it without laceration. When attacked the octopus changes color with great rapidity from black to gray, and when enraged it often has the appearance of a leopard. Then it hurls a cloud of ink into the water, and endeavors to slink away under this cover, gliding through crevices that would seem entirely too small to admit so large an animal.

The octopus swims when forced to do so, using a weblike membrane which is seen to connect the base of the eight arms or by forcing water from its siphon. These arms, when extended, give the octopus a faint resemblance to an umbrella without a handle, and with very long supports. The octopus preys upon very small animals, particularly crabs. I have lain among the bowlders on the shores of the Californian islands and watched the octopus hunting. They selected the flood tide and crept near the shore, moving along slowly, on the watch for a species of Grapsus very common here, a land crab which occasionally enters the water. The crabs crept down to the water's edge, and often entered, and in this moment of incaution were pounced upon by the disagreeable creature so well named the devilfish. Sometimes they were caught at the very edge; a long, livid tentacle would come shooting out of the water like a flame and seize the victim. Despite its struggles, it was soon hauled in, the octopus immediately covering it with its umbrellalike bag, doubtless bringing its nippers into play. I have seen an octopus dash out of water two or three feet and scramble up the dry rocks with remarkable speed after an escaping crab. At these times the octopus can be caught by seizing it quickly, but some experience is re-

Some would apparently play with my hand, tapping it with their tentacles, or gripping it gently. Others would crouch like miniature tigers, quivering with rage, and with green eyes shining, would spring upon it and attempt to smother it with their arms — a most disagreeable sensation, especially when it was almost impossible to remove the hand from the uncanny grasp without lacerating their flesh. One large octopus in this family, when it obtained a grip,

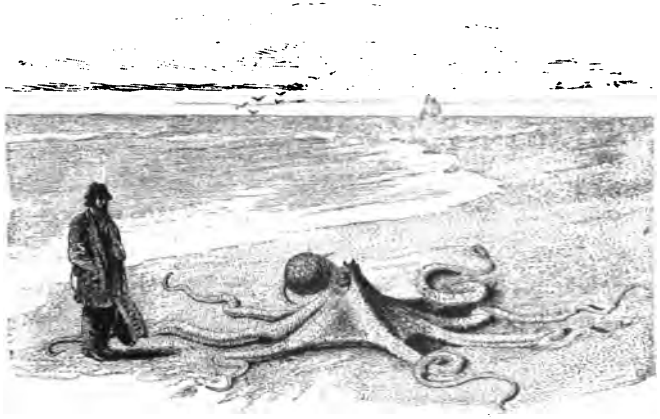


FIG. 123. — Giant octopus, radial spread twenty-two feet.

would hold my hand firmly; hence I concluded that a specimen thirty feet across, similar to those represented by casts in the Yale and National Museums, might easily overcome a man. Yet the octopus is a very timid animal in the open water. I rarely caught them either in Florida or California, unless they were cornered, and they never attempted to bite. But I seized one in the coral, and it wound about my arm so tightly that I was obliged to wrench away twenty or more pounds of branch coral, before

In many of the fossil deposits are found gigantic shells resembling the wheels of a cart, and enormously heavy. These are ammonites (Figs. 125, 126), and ancestors of the nautilus (Fig. 127), another member of this wonderful family of animals, with feet attached to their heads. It has a shell of radiant pearl, divided, like the little Spirula, by pearly septa or partitions, into rooms or chambers (*C*) all of which surround a small tube (*s*) called the siphuncle. This contains a long, fleshy pedicel, hence the nautilus is attached to its shell and can not leave it. The shell chambers are filled with gas, and the animal has the power to change its specific gravity, to float or rise. The nautilus forces itself along by a current from its siphon, and in a general way re-

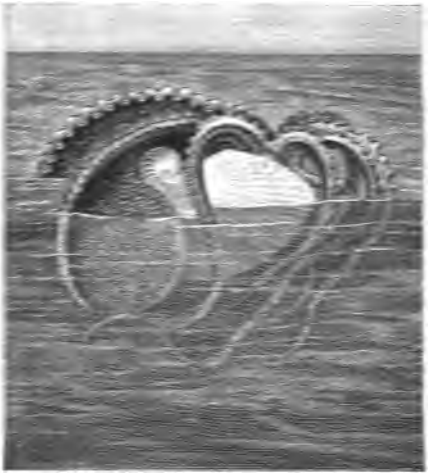
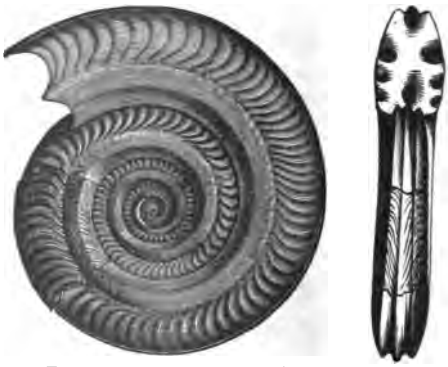


FIG. 124.—Argonaut in natural position, arms holding the shell.



FIGS. 125, 126.—Sections of an ammonite.

sembles others of the group. It has no ink bag, and its eye is not the striking object seen in the other forms. It is merely an elevation bearing a minute hole which leads into the globe of the eye, which during the life of the nautilus is filled with water. According to Doctor Hensen, in place of a refracting lens and a cornea, the animal has an arrangement for forming an image on the principle of a pin-hole camera. We might imagine the nautilus easy to capture; but it is very timid and rarely caught. Instead of eight or ten arms the nautilus has ninety-four. The shell is a beautiful object when cleaned and polished, being a vase of pearl of a chaste and elegant design, often copied, and in great demand by native artisans who carve and engrave it, and mount it in gold and silver. The nautilus, aside from its beauty, is a most interesting animal, being the last or almost the last of its race of fifteen hundred species, which have lived in former periods of the earth. Only two are still alive, and these in all probability are doomed to extinction.

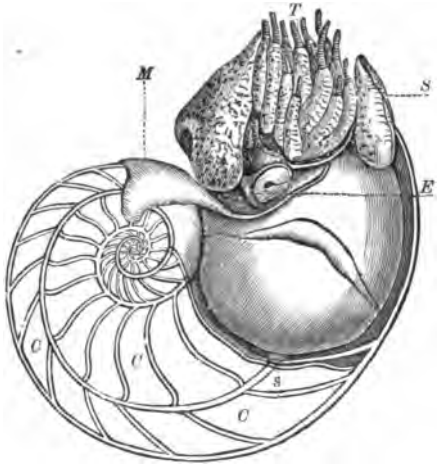


FIG. 127. — Pearly nautilus: *T*, tentacles; *M*, mantle; *E*, eye; *s*, siphuncle; *S*, siphon; *C*, chambers.

XIV. THE CRUSTACEANS

Among all the animals few are more interesting and whimsical than the crabs and lobsters. They have jointed legs, feelers and claws in pairs, living in a shell which they cast like an overcoat when they outgrow it, and have bodies which are made up of hard, tough, limy rings or segments (Fig. 128). The crustaceans are found in all waters, fresh and salt, and on land. They abound in the greatest variety, and range in size from specimens almost invisible to the naked eye to forms with a radial spread of over twenty feet.

During a recent visit to the outlying islands of the Texan coast, I found these extensive regions populated by vast hordes of white or yellowish land crabs, which paraded the beaches and climed over the dunes in such numbers that the eyes could not be raised without seeing a dozen or more. They were so familiar and tame that several large individuals had burrows by the side of the walk which led from the hotel, and readily took bread thrown to them.

On the keys of the Florida Reef the "spirit crabs," as they are called, are equally common. Pretending to be asleep, I have often watched them cautiously approaching, led by their curiosity to see what strange object this was that had washed ashore. If I remained perfectly quiet, they would gather in dozens, and numbers of little hermits would crawl over me, to drop off at the slightest alarm. In the water were countless other forms.

Wherever we go, from the ocean to the interior, we shall find some members of this interesting family. On almost any seashore we shall find a crab or crayfish, from which

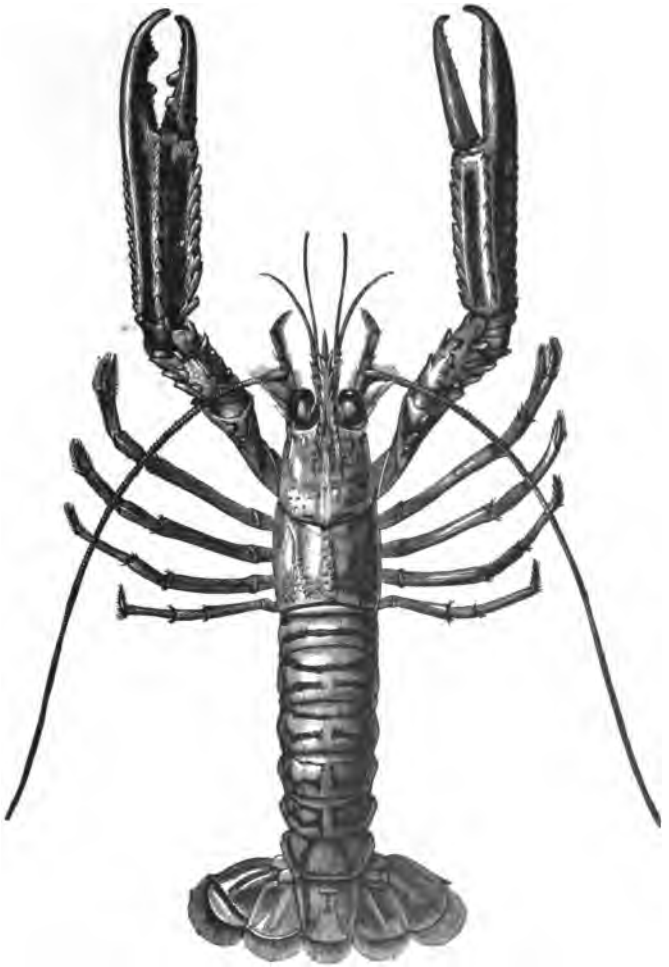


FIG. 128. — The Norway lobster, showing jointed structure.

some idea of the structure of these animals can be obtained (Fig. 129). We see that there are two distinct regions, the head portion and the tail. The first mentioned is hard and in one general piece; the latter is made up of joints or rings. Everything about this curious animal is jointed. Turning it over (Fig. 130), we see that it has five legs on

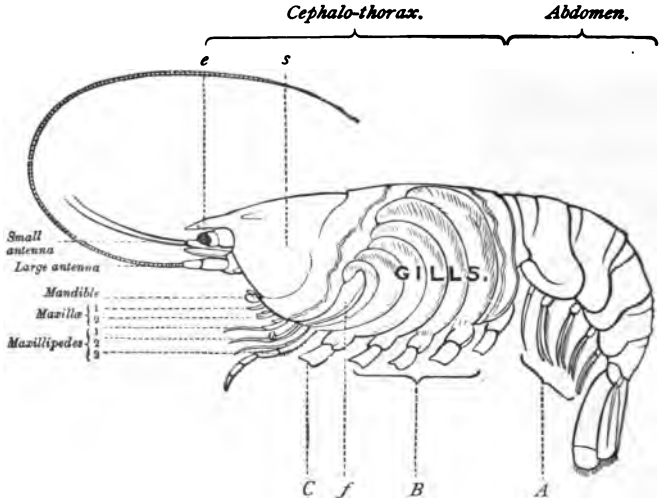


FIG. 129.—Crayfish seen from the side, with that portion of the carapace removed which covers the branchiæ, or gills. The appendages of the left side only shown. *s*, region of stomach; *A*, abdominal appendages; *B*, bases of the four small legs; *C*, base of large claw; *f*, "gill-bailer," or flabellum, attached to the second maxilliped; *e*, eye. (After Morse.)

each side, all jointed. The first pair are large biting claws, and in some species others are biters. Even the eyes are upon stalks and jointed, and about them are two sets of feelers, whips, or antennæ — one large and one small pair — which the animal holds out before it as a blind man does a cane. The mouth is made up of many curious organs for separating and grinding food.

Some idea of the various internal organs of the crustaceans may be obtained in Figure 131. The breathing organs

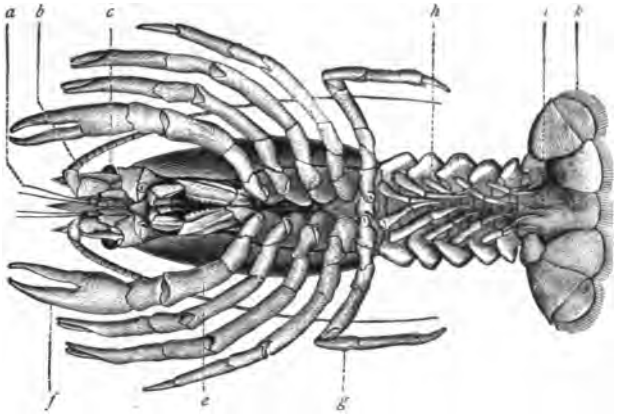


FIG. 130. — Under surface of the crayfish or fresh-water lobster (*Astacus*): *a*, first pair of antennæ; *b*, second pair; *c*, eyes; *e*, foot jaws; *f*, *g*, first and fifth pair of thoracic legs; *h*, swimmerets; *i*, anus; *k*, caudal fins.

are conspicuous, curled up like plumes on each side of the crayfish and attached to the base of the legs. Water enters the shell under the edge, back of the great claws, and is swept along over them by a little organ called the gill bailer, the gills taking up oxygen from the water, which in turn is absorbed by the colorless blood. The brain is very small, and nerves can be seen passing from it to the various organs. The ears are situated at the base of the small or first antennæ, and are little sacks on the upper side

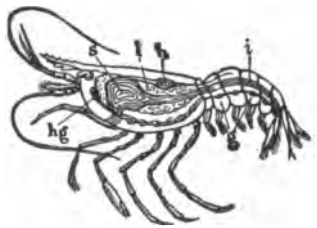


FIG. 131. — A shrimp, showing anatomy: *s*, stomach; *l*, liver; *i*, intestine; *h*, heart; *g*, chain of ganglia; *hg*, head ganglia.

containing a thick fluid in which are floating minute grains of sand. The tail portion is made up of a number of rings or segments, and is provided with small swimmerets. At the extreme end are seen five paddlelike or fanlike organs (Fig. 132), which constitute a most important swimming organ to the lobsters and crayfishes, by the violently flapping of which they dash away backward. In color the crayfish is yellowish brown or greenish. When alive it presents (Fig. 133) an attractive appearance.

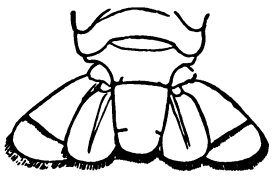


FIG. 132. — Paddles of lobster.

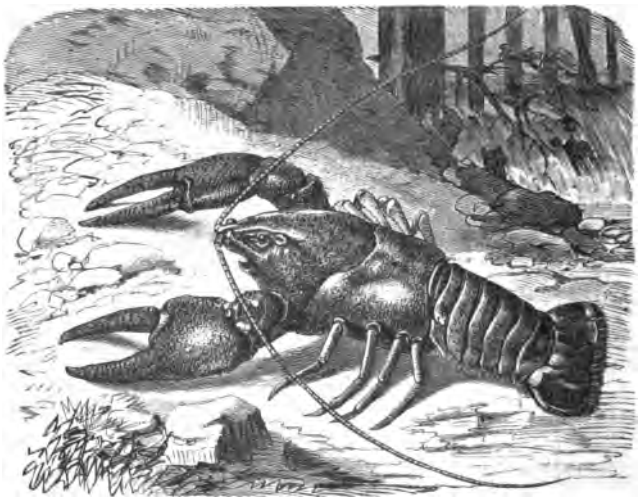


FIG. 133. — Fresh-water crayfish.

The crustaceans deposit eggs which they carry about with them attached to the swimmerets, and resembling minute bunches of grapes. When first hatched (Fig. 134)

the young crustaceans are totally unlike the parent in appearance, passing through several stages before they reach the adult form. When the crustacean grows too large for its shell, what are known as casting hairs appear on the inner side, which push the shell upward.

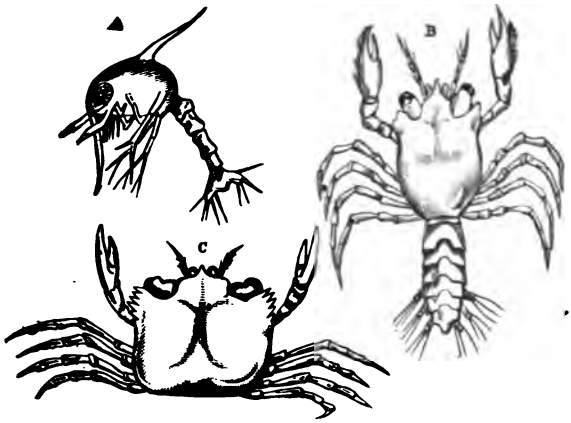


FIG. 134.—Stages of development in a crab.

I have watched this process in the California sea crayfish, and it is generally accomplished at night. The flesh of the animal appears to become very watery and soft at this time. Finally the animal bursts the shell and by a slow and convulsive effort drags the flesh from claws, eyes, swimmerets, and antennæ, and escapes through the upper portion of the division between the head and tail, and presto! we have two animals; one flabby and very nervous, the other the deserted shell, yet seemingly alive. The crayfish is very helpless now, and secretes itself for several days until the new skin hardens, when it appears in a freshly colored coat of yellow and black.

XV. FROM BARNACLES TO LOBSTERS

In strolling along the shore one may often find pieces of wood washed in by the combing waves, which are covered with white and blue-tinted objects, resembling dates (Fig. 135). They have long, fleshy stems, and appear to

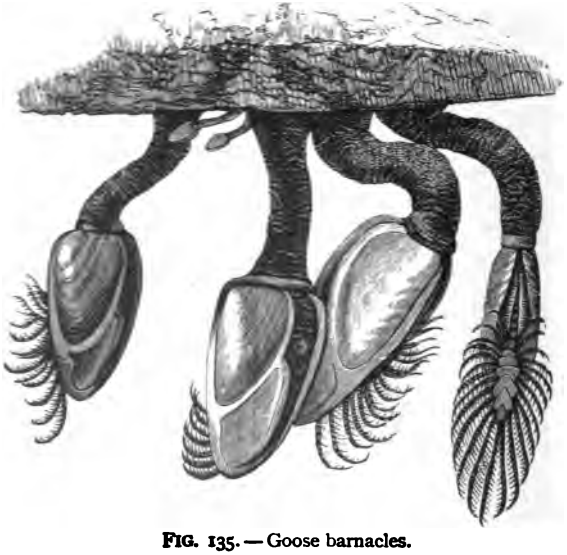


FIG. 135. — Goose barnacles.

have a number of plates or shells, and are by many considered shells. Other floating matter will be found covered with small white objects (Fig. 136), and many of the rocks alongshore are so completely encrusted by them that the surface of the rock is concealed. On the backs

of whales are found similar objects, often three inches across and two inches high. These are barnacles, cousins of the crabs, which secrete multivalve shells and are anchored to various floating or submerged objects. They are crustaceans which are attached to the bottom by their antennæ.

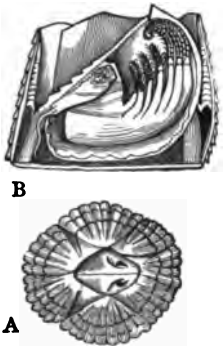


FIG. 136. — The barnacle: *A*, from above; *B*, section from the side.

If the shell of a barnacle is carefully observed, fluffy, feathery objects may be seen coming out with regular motion. These are the feet of the crustacean, which in the barnacles are modified into food catchers, grasping at the minute animals contained in the water. What are called goose barnacles have long stems, and the old writers considered them young geese which grew on trees and finally fell into the water. I have found a goose barnacle in the mouth of a large sunfish, so placed that the barnacle swung clear of the curious teeth of the fish. They are also found on the feathers of penguins in the South Pacific. Every floating timber or wreck at sea is covered with the curious, long-stemmed creatures. The barnacles deposit eggs, and the young are at first free swimming, but soon acquire a shell, seek the bottom, or some floating object, and become fixtures for life.

Many of the crustaceans are so small that but few persons ever see them. Such is Cyclops (Fig. 137), a minute creature seen distinctly only under a microscope, yet swimming in fresh water and readily recognized by its egg pouches, one on either side of the tail. The eggs hatch

out into singular little objects, having very little resemblance to the parent. The Cyclops and others are very tenacious of life. When pools and streams dry up and remain so for months, they lie dormant, coming to life again with the return of the water. Many of this group are parasites upon fishes, as the Lernæidæ (Fig. 138), which appear like streamers on the sides of carp and other fishes. These parasites, deeply embedded, live upon the fish.

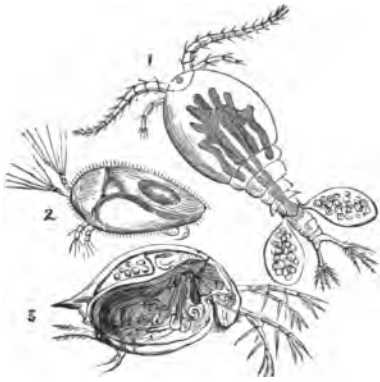


FIG. 137. — Water fleas: 1, Cyclops, showing egg pouches; 2, Cypris; 3, Daphnia.

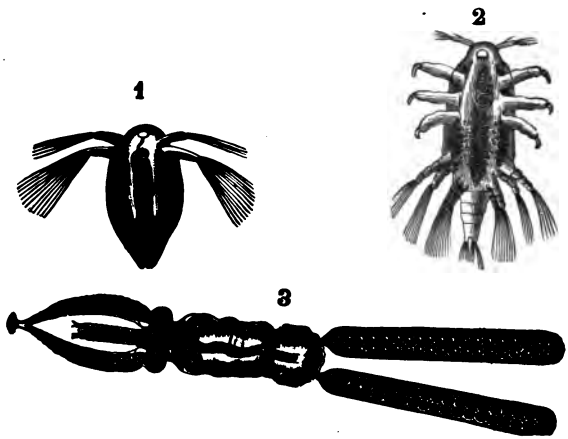


FIG. 138. — A parasite of a fresh-water fish (*Cyprinæ*): 1, larva, as it leaves the egg; 2, larva, more advanced; 3, adult female, showing the egg sacs. (Nordmann.)

Some of these minute crustaceans are almost exact in their resemblance to shells, as Estheria which has a bivalve shell. But perhaps the most remarkable creature is Artemis, the brine shrimp (Fig. 139), which lives in brine that would be deadly to almost any other animal. A strange experiment has been made with this little creature; thus if the brine is very strong its form resembles *a*, but if the brine is diluted, it changes to *b*, a very different animal, so different that it has been given another name. Many shrimps seem to prefer extreme cold. The Apus (Fig. 140), withstands freezing, and hatches readily in the icy water of the far north. This little creature has forty-seven segments and one hundred and twenty legs. The fairy shrimp is a dainty and beautiful crustacean with a marvelous array of leaflike feet which also serve as breathing organs.

FIG. 139. — Brine shrimps: *a*, Branchipus; *b*, Artemis.

FIG. 140. — Apus.

In the summer, while strolling alongshore, one may find that every piece of seaweed or rock when turned over affords concealment to myriads of "sand fleas" which belong to a group of crustaceans having fourteen feet. The sand fleas, true to their name, are remarkable jumpers,

darting in all directions and looking very much like an ordinary flea (Fig. 141). They are valuable scavengers, eating all kinds of refuse matter. They have the most bizarre shapes, and many, as Arcturus, resemble twigs or pieces of sea-weed, extremely difficult to see and doubtless owe their immunity from attack to this cause. This Arcturus (Fig. 142) is not only a remarkable mimic, but carries its young upon its back. Idotea is a common form about piers, while the little Gammarus may be caught with almost every haul of a very fine net. At times one known as Podocerus builds a singular nest for its better security, and one of the giants of the tribe has eyes so huge that they are made up of facets and entirely cover the head.

FIG. 141. — Sand flea (*Talitrus*).

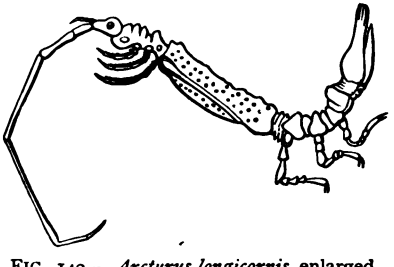


FIG. 142. — *Arcturus longicornis*, enlarged.

One of these crustaceans, Limnoria, is among the most destructive of all animals to the work of man. On the Pacific coast they vie with the teredo, and on the coast of southern California are the chief aggressors, the life of a prepared pile being less than two years. The little creatures completely perforate it, so that the wood literally falls in pieces, being so closely filled with circular borings that the entire interior of the pile seems to have disappeared.

One of the most beautiful of all the crustaceans, in my estimation, is the mantis shrimp, or Squilla (Fig. 143), which I have kept alive. It is found in deep and shallow water, and is a most remarkable creature both in shape and color. Its head is ornamented with beautifully tinted antennæ, vivid blues, greens, and yellows predominating. Its claws are sharp pointed, and deadly weapons when used against its prey. The finlets are richly tinted and in such rapid motion that they appear to be a mass of revolving wheels, so that the Squilla resembles some strange product of the imagination rather than a living animal. Its young are even more remarkable.

FIG. 143. — Mantis shrimp (*Squilla*).

One of the best-known groups of crustaceans is represented by those with ten feet, of which the common lobster (Fig. 144) is a familiar example. In this instance the first pair of legs are developed into enormous biting claws; yet when the lobster sheds its skin all the flesh in the large claws is drawn through the very small joint. The lobster is a product of the colder waters of the North Atlantic, not being known on the Pacific slope, although attempts have been made to introduce it there. South of Long Island Sound it is very rare, and despite the stringent laws for its preservation, is rapidly being

exterminated. Lobsters are caught in traps, called lobster pots, which are lowered into the kelp and seaweed.

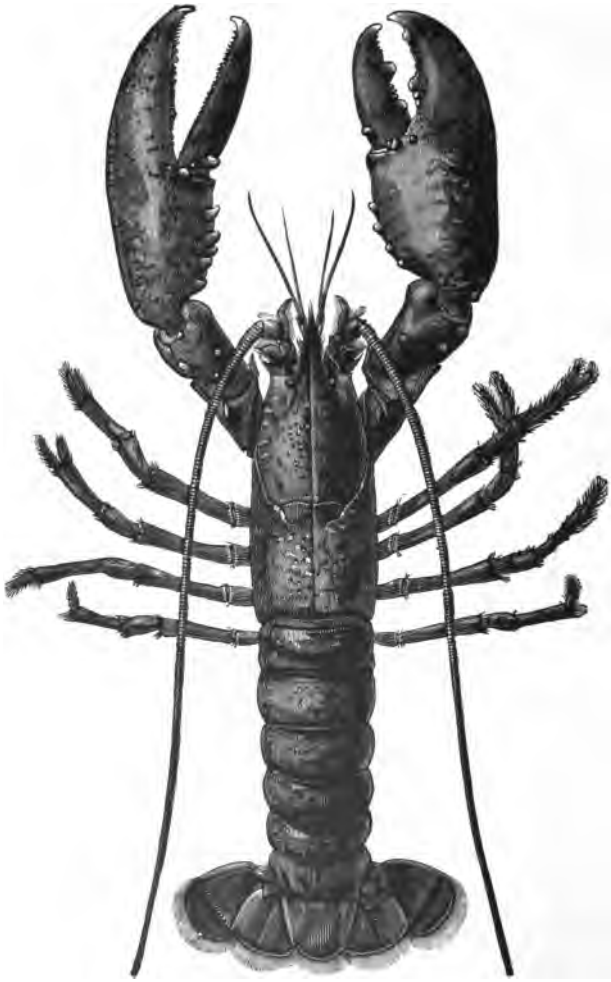


FIG. 144. — Common lobster.

Twenty years ago the annual catch for the state of Maine was nearly fifteen million pounds, valued at $250,000. It is far less to-day. The lobster sometimes attains a weight of fifty pounds; but specimens weighing four or five pounds are now rare, due to overcatching, and the destruction of the undersized young. The color of the animal when alive is a dark green. The familiar red hue is the result of cooking. The eggs of the lobster are laid in March, and are masses of green spheres which are carried about by the female attached to her swimmerets.

In southern waters and on the Pacific coast, the place of the lobster is taken by the crayfish, or spiny lobster (Fig. 145). The resemblance to the lobster is almost exact with this exception: instead of large biting claws, the latter are but slightly larger than the ordinary claws, ending with a sharp point, while the antennæ or feelers are enlarged to an extraordinary degree, becoming highly serrated and defensive organs in every sense. The Florida crayfish is a rich reddish yellow, mottled color, while the California form is a greenish yellow. On the Florida Reef almost every coral branch or coral head hides a crayfish, the whips being seen waving to and fro. This is their day retreat, but at night they wander forth to feed in the luxuriant pastures of Algæ, or seaweeds, of various kinds found in the lagoons. By going out early in the morning, before sunrise, I have often surprised the crayfishes, the bottom being covered with them, massive fellows weighing eight or ten pounds. They are not so delicate in flavor as the lobster, but are very valuable as bait. The lobster and the Pacific crayfish are both canned, the industry being an important one.

The prawns (Fig. 146) and shrimps are well known and valuable members of this group, swarming in the same

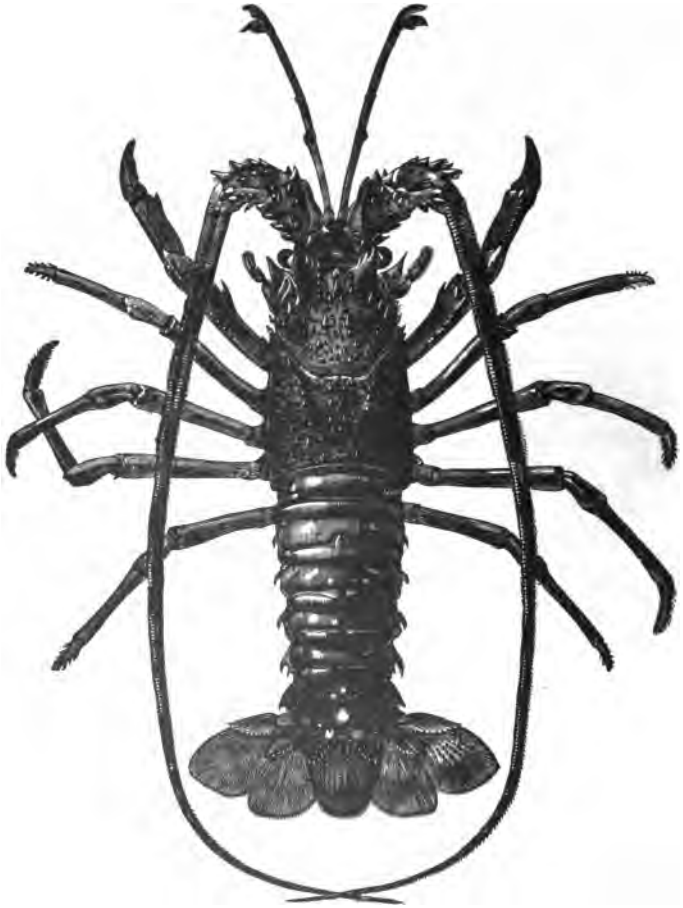


FIG. 145. — Crayfish or spiny lobster.

waters, and among the most graceful of the tribe. Many are absolutely transparent, the large black eyes alone being

seen. The chameleon shrimp is noted for its rapid changes of color, green, brown, and reddish hues following each other over its crystallike body. In the deeper waters marvelous shrimps have been found, nearly all a dazzling red. Some of the East Indian shrimps are giants two

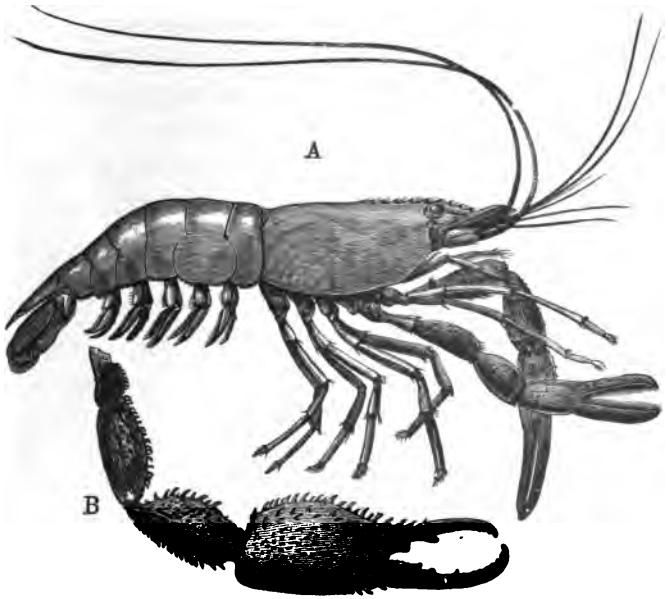


FIG. 146. — *A*, prawn; *B*, claw enlarged.

feet in length. In England horses are employed to catch shrimps. A large dragnet is set in shallow water to which the horse is fastened, the fisherman, mounted, driving the animal over the shallow flats, hauling the nets inshore.

One of the most interesting of these ten-footed crustaceans is the blind crayfish of Mammoth Cave. It is

found also in various subterranean streams of the country. The eyestalk of these little creatures is all that remains to tell the story of what was once an eye, and they live and thrive in perfect darkness. The ordinary crayfish of Western streams has a peculiar habit of burrowing, which at times has occasioned great damage in undermining dikes and dams. I once came upon a remarkable crayfish community in Indiana. There had been a flood the day previous, and every log in the neighborhood and the piers of the bridge were covered with crayfish which, in this locality at least, appeared to be endeavoring to escape from too much water. On all sides, some yards from the creek and high above it, the ground was raised into small heaps six or eight inches across, each, as I discovered, being the home of a crayfish, and as far as the eye could see on the prairie were these mounds and heaps, suggestive of the vast numbers of these little animals in this vicinity.

XVI. THE CRABS

Of all the crustaceans, the crabs are the most singular and certainly the most intelligent. Rapid in movement, good swimmers, alert, garbed in extraordinary colors, often in stolen homes, they attract attention at once and are the harlequins and clowns of the animal kingdom. The crabs are distinguished from the rest of the group principally by their very short tails. Their bodies are round, elongated, or oval. They are found almost everywhere, from the deep sea, where they occupy shells and sometimes drag about a luminous sea anemone, to every beach. It is in or near the tropics that the most remarkable crabs are seen.

During a visit to the islands off the coast of Texas, I once found a remarkable crab community. The islands were flat sand banks just above the surface, blown and washed up by the sea, with here and there sand dunes and shrubs, and again vast stretches of sand inhabited only by crabs. The latter were all of one kind, a pale gray, so mimicking the sand in color that it was almost impossible to distinguish one from the other. There were legions of them, the sand in places being fairly riddled with their burrows, into which they darted with inconceivable rapidity. As I walked along the sands they ran ahead in rapidly increasing numbers, then divided and were so quick of foot that it was impossible to run them down. This vast army of crabs was the sanitary corps of the island,

devouring every dead fish that came ashore and other animal matter of all kinds.

At Garden Key, Florida, these crabs were found in swarms, rarely entering the water except when driven, and never venturing far from the reach of the highest waves at high tide. They had long, stalked eyes, which seem to follow every movement, and were very comical and interesting creatures to watch and study. On the keys covered with bay cedars were other land crabs (Fig. 147),

FIG. 147. — A land crab (*Gecarcinus*).

colored rich red and purple. These crabs lived among the cactuses and bay cedar bushes. When climbing on the former their resemblance in shape and color to the purple fruit was remarkable, and if the crab remained quiet, it was almost impossible to distinguish it. In these bushes a tern, the noddy, had built its rude brush nest, and the young bird and the food brought it by the parents were the objects of marked attention on the part of not only the purple-backed crab but a hungry, starving horde of hermit crabs which climbed the tree and snatched the

bits of fish from the young birds, despite the presence of their mother. By crawling beneath the thick brush in heat which was almost suffocating, I watched numbers of these foraging expeditions on the part of the crabs, and I think it possible that some of the larger crabs finally carried off the young birds. This was not an impossible feat, as Professor Mosely, of the *Challenger* deep-sea dredging expedition, observed the same crab or a very near relative, carry off young birds at St. Paul's Rocks. At Ascension he saw the doughty land crabs stealing young rabbits, dragging them from their holes by main force and devouring them. This crab with gorgeous colors was not very fleet of foot, and when I rose up suddenly in the cactus by a nest they would draw in their legs and cling to a branch, mimicking ripe fruit. The hermits would do the same, and fall to the ground in a shower.

An interesting crab found here is known as Grapsus, also a predatory creature with unequaled courage, preying upon every living thing that it can attack with safety. It is richly colored red and white; its legs are long; it is a racer along the sands, impossible to capture. On the West African coast these crabs, or a near relative, are very large, and so swift that they have been used in sport, horsemen following them at full speed as game.

The ordinary crab of the Eastern shore is highly valued, and vast numbers are shipped from Fort Monroe in Virginia to the northern cities. The trade in "soft shells" is even more important. The latter are caught in various ways. An old colored man of my acquaintance used to tread for them on the mud flats with his bare feet; but he

confessed that it was a disagreeable business, as sometimes he stepped on "hard shells" by mistake and was badly bitten.

The English edible crab is of large size and always in demand, resembling the edible crab of the Pacific, which is also very large and greatly esteemed.

That these crabs have a strong homing sense, or an affection for certain localities, was demonstrated some years ago. Two crab fishermen were following their occupation from the same boat, and each as he caught a crab cut upon its swimming claw a private mark so that they could be claimed by the rightful owners at the end of the day. The boat was overtaken by a storm and the crabs were tipped overboard five miles from where they were caught and lost. The following week the two men again began to fish in the original spot, and to their amazement began to catch the marked crabs, which had returned five miles alongshore to the locality of their choice.

The so-called green crab (Fig. 148) is an attractive and active creature, one that can easily be observed. Its quaint stalked eyes, which turn this way and that, and which can be stowed away in little depressions, and its singular method of walking, are very interesting features. When a crab walks on land it is usually endwise, and when it wishes to change its course it is not obliged to turn about but moves its legs in the opposite direction. It can also move directly ahead. These movements are all performed by six legs, which are pointed, the trail of this crab on the sand resembling pin marks on the hard beach. The two front claws are for tearing food and for general defense, while the last pair, widened out at the end

in some, are paddles by which the crab swims when it ventures off the bottom.

At times the crabs appear to migrate. I have seen the bottom of a bay on the Virginian coast so covered that it was impossible to wade without stepping upon a crab. In the island of Jamaica certain land crabs march to the sea

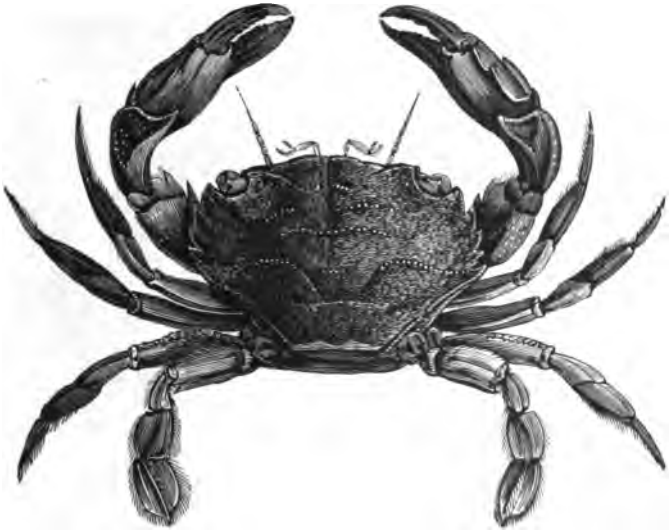


FIG. 148. — The green crab.

to deposit their eggs, at which time they appear more or less indifferent to danger, and move on, despite the attacks of birds and various animals, including man.

The crabs known as fiddlers (Fig. 149) are common up and down the Atlantic coast, especially in the warmer portions. A most interesting colony lived north of Fernandina, Florida. Some years ago a plank walk led across their domain, and one could stand and watch their

ludicrous maneuvers. The fiddler is not over an inch in length. It is of a dark ivory hue, and its eyes are perched on long stalks, so that it can bury itself in the mud and thrust its eyes upward, and thus in perfect safety observe everything that is going on. The right claw of this crab is half as long again as its entire body — a colossal weapon framed for an animal five or ten times its size. Indeed, it is so large as to be almost useless, for a large amount of

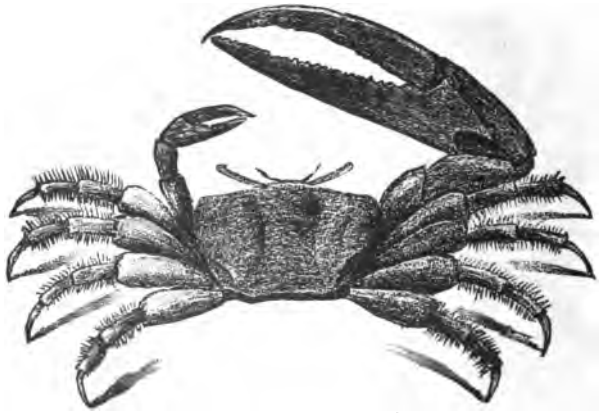


FIG. 149. — Fiddler crab.

strength is required to operate so gigantic an implement. To emphasize the undue size of this claw, the left one is a dwarf, being too small to act as a defensive weapon. How so small a crab can use so strange a pair of weapons was a puzzle, until by watching them, I discovered that the crab uses its large claw as a bogy, brandishing it fiercely, which gives it a very ferocious appearance. The movement of the claw back and forth is called fiddling, hence the name of the crab, which appears to be constantly

fiddling. Where hundreds are seen, all fiddling and mena cing one another at the same time, the sight is laughable.

Once while lifting branch coral into my boat on a coral reef, several crabs fell from the olive-hued mass, and like spiders in shape and form, made their way slowly along. Each one was covered with a growth of seaweed. I

FIG. 150. — Spider crab.

took a brush and scoured them, producing veritable spider crabs (Fig. 150). The body was pear-shaped; the claws were long and covered with sharp points. These crabs were placed in a tank, and almost immediately began to replace the seaweed which had been rubbed off, evidently being much annoyed at the cleaning process.

In redecorating themselves they broke off small bits of seaweed from a branch, placed the broken portion against the mouth, evidently to attach some glutinous matter or animal mucilage, then raising it with an overhand movement, they attached it to the back. This was continually repeated until within a few hours the back of each crab was changed from a smooth surface to a miniature garden. As many times as the seaweed was removed, so many times was it replaced.

The spider crabs range from the beautiful scarlet creatures found in the coral to the giant Macrocheira of Japan, which in large specimens has a spread of legs of twenty feet, some measuring twenty-two feet between the two large biting claws, each of which is ten and a half feet long. This huge crab is very slender, and is slow of movement, its body resembling a rough rock.

Crabs select singular places for homes. One lives in the sea cucumber; others live in corals, which appear to grow over them, forming a gall (Fig. 151). The little oyster crab found in bivalves is a familiar form. But perhaps the most remarkable home for a crab was the bowl of an old tobacco pipe in which a crab I once owned ensconced itself. This was a hermit crab (Fig. 152). The hermits differ from other crabs in having a long, but soft and totally unprotected tail or abdomen, to preserve which they enter empty shells and drag them about wher-

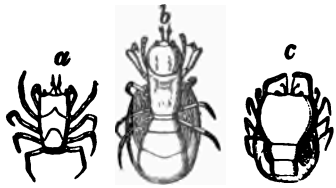


FIG. 151.—Crabs that form galls on corals: *a*, *Cryptochirus* (male); *b*, *Coralliodytes* (female); *c*, *Hapalocarcinus marsupialis* (female), that carries its young in a sac or marsupium.

ever they go. The hermits occur in great variety, and there are marine hermits and land hermits. On the Florida Reef they are found in myriads; every shell alongshore conceals a baby hermit; and almost every nook or cranny affords concealment for a score of them, their red and blue claws forming an attractive contrast to the shell.

The hermit referred to was first found in a pearly shell and placed in the office, but finally it outgrew this and deserted it for the pipe which some workmen had left on the

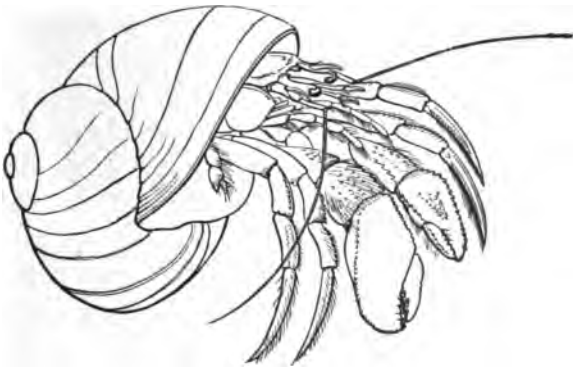


FIG. 152. — Hermit crab.

floor. Every day this old pipe would be clanked and dragged about the room, and once in a while the crab would drag it up a table leg, so reaching the tablecloth and then the table top, where it drank out of a saucer left for the purpose. Later a marine hermit was found in a pipe bowl, proudly dragging the grotesque house about. Anything of this kind would be used by the hermits. One was found in the opening of a spool; and this would roll over and over, carrying the hermit with it. Another took pos-

session of a reed. Among deep-sea sponges the hermits are seen occupying holes in the sponges.

A community of hermits is a laughable sight. They are very pugilistic, and are always fighting. When a hermit outgrows its shell and begins to feel uncomfortable it endeavors to turn out some comrade that has a larger shell, and in the battle arms and claws are often lost. This, however, is not serious, as they grow again. When the hermit finds an empty shell it thrusts in its claws and antennæ, probing it in every direction to see that it is not occupied. When satisfied, it jerks itself out of its own shell, and with the greatest rapidity whisks its soft unprotected body into the new house, where, if it fits, it remains. The shell, when large, is not carried, but dragged about, and when the crab is alarmed or startled it darts backward into the shell, where its large claw and the others constitute almost as good a door as the real operculum of shells. The largest hermits are the marine forms, which enter the large conch shells and drag them about. These hermits are a brilliant red in color. Their claws are very rough.

Closely related to the hermit crabs is the famous cocoanut crab or Birgos of the Spice Islands. This crab is so strong and powerful that, as Professor Van Beneden states, one clinging to a tree, seized a small goat and lifted it from the ground by the ears. The Birgos resembles a huge hermit crab, but has no artificial shell, the soft abdomen being protected by a shell of its own. This large land crab lives mainly on cocoanuts, which it secures by climbing the trees and biting off the stems. Descending, the crab will take the nut and with remarkable discrimination hold it with one claw and with the other

tear off the husk, always at the end containing the "eyes." This stripping process, impossible to man without some implement, is remarkable in itself, and tells the story of the muscular strength of the crab. When the "eyes" of the nut are exposed, the crab seizes it by inserting its claws in the holes, and hammers the shell until it is broken. The crabs live at the base of the trees and line their dens with the husk.

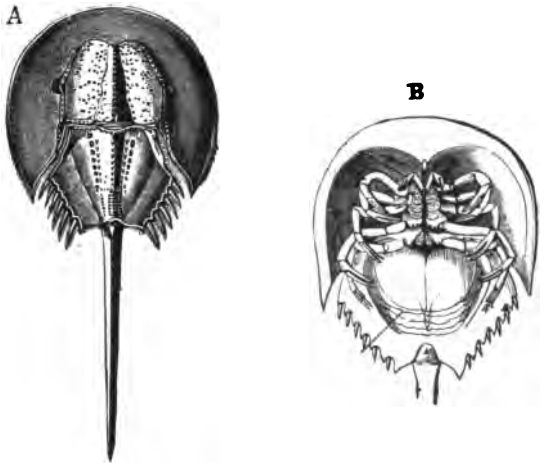


FIG. 153. — Horseshoe crab: *A*, upper side; *B*, lower side.

In ancient times crablike creatures existed, eight or nine feet in length. These are represented to-day by the quaint horseshoe or king crabs (Fig. 153). They are found in shallow water in Northern waters, and resemble a horseshoe with a long, sharp spike or spine — the tail of this strange animal.

XVII. LUMINOUS CRABS

One of the interesting experiences of Nordenskiöld in the Arctic Ocean was wading through the sludge, as the soft snow water along the beach is called, and seeing each footprint turn into a mass of light, caused by the phosphorescence of a small crustacean called Metridia. The light was bluish white, of great intensity, and although at times the cold was so severe that mercury would freeze, yet everywhere this marvelous light blazed. Even drops and splashes of the water seemed to be molten metal, but were merely alive with this minute light giver resembling Cyclops. In the Pacific, especially in summer, the exhibition of what might be called "crab light" is marvelous, and this is often true in the Atlantic. The light following the splash of an oar, the spray hurled aside by the cut water, the foaming water around a propeller, and the strange shifting specter which follows the rudder, are caused more or less by minute crustaceans which have the faculty of emitting light without heat.

Along the beach beneath seaweed, we shall find Gammarus, a long, very small, but mighty jumper, that at night emits a red light. Many of the near relatives of this little creature are phosphorescent, and perhaps the most beautiful of all is one named Idotea phosphorea. It is a yellowish spotted little creature found in pools alongshore. It darts about among the weed, and would rarely, if ever, be noticed during the day; but at night the entire animal seems

permeated with a golden light which marks it in vivid lines against the dark bottom, and flashes and miniature meteors indicate it as it dashes across the little pool, its ocean world.

The most beautiful of all crustaceans is the one known as Sapphirina. I have seen the ocean filled with them; some red, others blue or yellow, purple or green, all known gems being imitated by these matchless gems of the sea, which in daylight vie with the most brilliant iridescence in producing wonderful displays. No more beautiful scene can be imagined than that embracing these living gems, standing out in brilliant tints against the deep blue of the ocean. These gems also have the gift of phosphorescence and at night appear in a new guise.

One of the singular long-legged spider crabs of the deep sea, Colossendeis, is said to be phosphorescent. Giglioli, the Italian naturalist, describes a crab which gives a golden purple light, the latter appearing from the thorax. The little shrimp, Mysis, which carries its young in a pouch, from which it is called the opossum shrimp, is not phosphorescent, but its young in what is called the zoëa stage are luminous. The odd-shaped little creature, which is the mantis shrimp in one of its stages, is brilliantly luminous, not over its entire body, but in the eyestalks. Some of the deep-sea crabs have luminous eyes, strange monsters wandering in the abysmal regions of the deep sea.

While most of these crabs have the light in only one place, one discovered by Sir Joseph Banks was luminous over its entire surface. Exactly what the luminous matter is, is not known, but in some instances it can be scraped

off and will render the hands luminous when rubbed upon them. According to A. M. Norman, naturalist of the *Porcupine* expedition, the crustacean Ethusa, found at a depth of eighteen hundred feet, is blind, its eyestalk being spiny, and the eye replaced by a smooth, round termination which is supposed to be a light-emitting organ. Aristeus has phosphorescent eyes, which blaze with the yellow fire of a cat's eye, and this is true of many other crustaceans. Some have luminous backs; others have fiery bands upon the legs, while almost every portion of the body of some species is the seat of this wonderful light. That the lights are of some use there can be little doubt. In one little creature Dr. Gunther found a brilliant light stationed between its eyes, which certainly was a light to illumine its way in the deep, dark bed of the ocean.

XVIII. THE INSECTS

AMONG the best-known and attractive members of the lower animal kingdom are the insects, represented by the gorgeous butterflies, the iridescent beetles, the fierce spiders, and many others. The crustaceans may almost

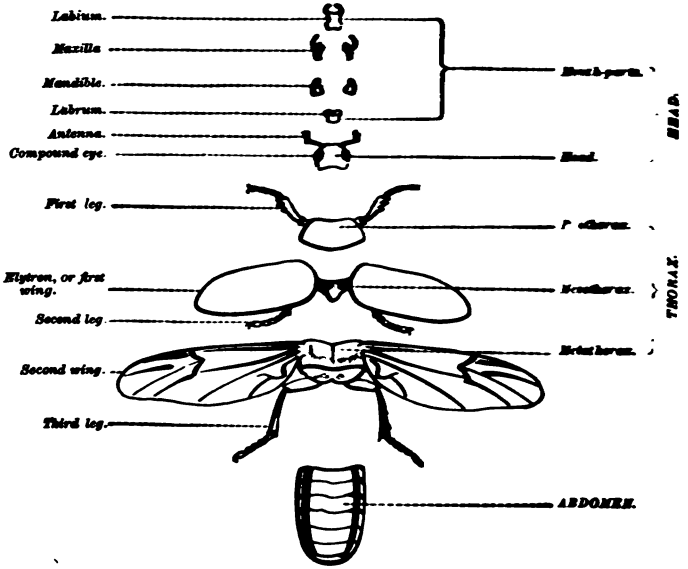


FIG. 154. — Parts of a typical insect.

be called the insects of the ocean, as in general appearance they closely resemble these animals; but the real insects are higher forms.

The skeleton (Fig. 154) of an insect is divided into three distinct parts instead of two. The head is distinct from

the body, as in the crabs, and the skeleton, like that of the crabs, is external, and formed of a horny substance called chitin. As in the crabs, the body is made up of rings, or segments: four in the head generally, three in the thorax, and ten or eleven in the abdomen. It is interesting to glance at the various parts of insects, and later on, in reading about the many species, to note the many different purposes to which each is adapted.

The mouth is a very complicated organ in the crabs, and equally so in the insects. It is generally separated into four distinct parts: the upper lip, labrum, the jaws, or mandibles, a second pair of jaws smaller than the above, and the lower lip or jaws, labium. These are formed into sucking organs in the mosquito, biting organs in the ant, and tremendous graspers in the centipede, all displaying the most remarkable variety.

FIG. 155.—Head of the grasshopper.

The eyes of insects are wonderful organs, being both simple and compound. In the grasshopper (Fig. 155) the two are easily seen, the compound eye being the larger. The fly has a remarkable compound eye (Fig. 156), and in the center of the two eyes are three simple ones. The compound eye in the fly is made up of vast numbers of six-sided eyes crowded together, appearing under a glass like a honeycomb; yet each of these facets is a complete eye. In a sectional view of the eye of a beetle (Fig. 157) we can see the nerve that reaches

FIG. 156.—Eyes of a fly.

every one. In using the eyes hundreds of images of the same object must reach the brain of the insect, yet the image of but one is seen.

Attached to the head of insects are various sense organs, feelers, or antennæ, which are very ornamental, as in the beetles. The central portion of the skeleton bears the wings. In the beetle the wing covers are formed of hard chitin. When its wings are not in use this insect stores them away in covers provided for the purpose.

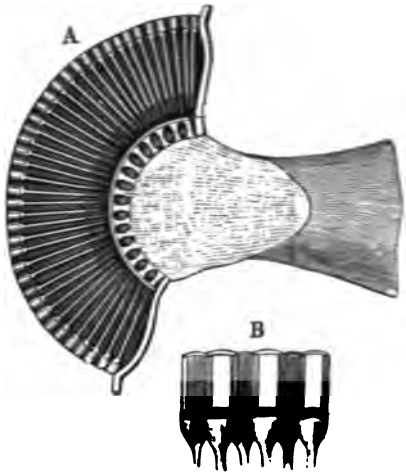


FIG. 157. — Sectional view of the eye of a beetle.

The third or last part of the skeleton, the abdomen, often bears a weapon of defense, as a sting or a drill for boring holes in trees, or machines for making silk, as in the spiders. Here also we find a remarkable variety of tails, ranging from that of the dragon fly to the long tail of the scorpion with its dangerous sting or dagger.

The feet of insects would make an interesting chapter alone, ranging from the curious, sucking, padded foot of the fly (Fig. 158) to the claws of others. The anatomy of insects is more or less complicated. The method of breathing is particularly interesting. It is very natural to imagine all animals breathing by the mouth or nostrils, but insects breathe by a singular system of air tubes (Fig

159), or tracheæ, some having lungs as well. The air tubes are wound with threads upon the inside. This preserves their shape and keeps them open. If we examine a grasshopper (Fig. 160), we shall see along the sides openings, which under a powerful microscope resemble eyelike organs (Fig. 161). These are air holes, windows, or spiracles, which lead to the air tubes, and by minute thread-lined tubes reach all over the body. To obtain air, or to breathe, the bee keeps its abdomen continually in motion, forcing air through the body, carrying oxygen to the blood tissues.

FIG. 158. — Foot of a fly.

FIG. 159. — Breathing tubes of an insect.

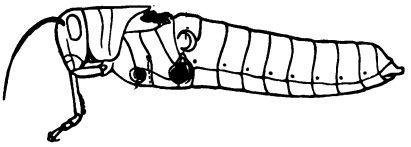


FIG. 160. — Grasshopper, showing spiracles, *s*.

The insects, with some exceptions, deposit eggs, and the young pass through many strange changes, or metamorphoses, be-

fore the full-grown form is attained. The eggs of beetles hatch into larvæ (Fig. 162), which may live weeks or months or even years in the ground. The eggs of other insects, as moths, may become caterpillars, which finally spin a co-

FIG. 161. — Breathing hole or spiracle, highly magnified.

FIG. 162. — Larvæ of insects.

coon, as in the case of the silkworm, and from this cell-like room appears the perfect moth. These changes, so infinite in their variety, are among the most interesting features of insect life, and are never failing sources of wonder and amazement on the part of those who devote time to the study.

XIX. LOWER FORMS OF INSECTS

In the previous chapter we have by the aid of illustrations glanced at the structure of insects, and noted some of the features which distinguished them from the crabs. Now we may take up some of the more important and interesting groups and observe how Nature has adapted them to their peculiar surroundings, and for the various offices they fill in the world.

In examining the various families of insects it is interesting to note that many produce certain results or accomplish certain ends in totally different ways. The highly organized spider by drawing silk from the spinning machines at the tip of its abdomen builds a web so strong that it sometimes captures birds. I recently found a living humming bird hard and fast in a web at the corner

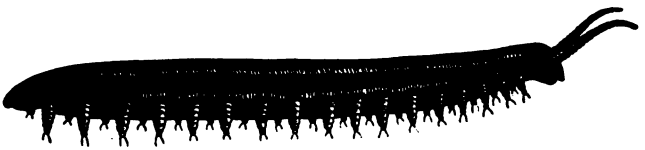


FIG. 163. — The Peripatus.

of my house, and released it just in time to save it from the spider. In the very lowest groups of insects we find the Peripatus (Fig. 163), which spins a weblike structure from glands in its mouth, ejecting the secretion at the insect it wishes to catch. This appears to crystallize in the air and hold the victim despite its struggles. The Pe-

ripatus, found in Africa and Central America, resembles a large caterpillar, having a long, soft, cylindrical body with many pairs of feet, sometimes sixty-six; the latter are soft and armed with claws. It is remarkable for the posses-

FIG. 164. — A milliped.

sion of many legs, but is outdone in this respect by the millipeds, as some (Fig. 164) have as many as two hundred. These insects, when placed upon their backs, present an extraordinary appearance, clawing the air; yet they are among the slowest of walkers. They live in the ground, are harmless, feed on vegetable matter, and deposit their eggs in the earth, which hatch out little creatures at first resembling crickets.

The centipeds, on the other hand (Fig. 165), are animal feeders, and those found in the tropics are formidable creatures from six to ten inches in length, supplied with

FIG. 165. — A centiped.

many claws and terrible fangs. They live a life of rapine and destruction, and the appearance of a large specimen almost a foot in length, dashing along with great rapidity by the aid of its fifteen or twenty pairs of feet, is sufficient

to demoralize the stroller through the dark glades of the tropical forests. They have two pairs of foot jaws (Fig. 166) which grasp an enemy with wonderful tenacity. The second pair is perforated, and from it pours a poison dangerous to man in some tropical species and fatal to small animals. Several of these hideous creatures are luminous at times. Many centipeds have long antennæ. The eyes are very small, and in groups. The ordinary centiped of the North is harmless, despite the tales related of its ferocity.

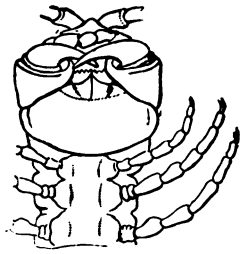


FIG. 166. — Under surface of head of centiped, showing poison fangs.

Among the very small, though destructive insects, are the mites, found in cheese and sugar; they are parasitic in cattle and various other animals. In California certain forms (Fig. 167) cling to the bushes.

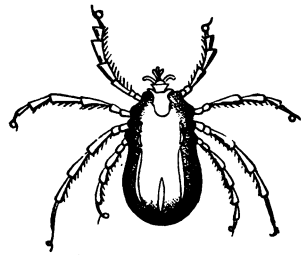


FIG. 167. — A mite.

In remarkable contrast to the round-bodied mites are the scorpions (Fig. 168), in which the tail is sometimes two inches in length and armed with a sharp, daggerlike sting, provided with a

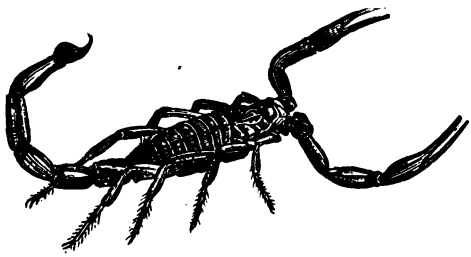


FIG. 168. — The scorpion.

poison apparatus. The scorpions of the largest size are often found in the tropics in the same locality with centipeds, under board piles and in dark places, coming out at night to prey upon small insects, which they seize with their crablike claws and tear apart. If the insect struggles violently, the scorpion raises its tail over its back and pierces it with its dagger, paralyzing it. In striking at other enemies the scorpion whirls about, keeping its tail toward them, repeatedly striking down and using its jointed tail with marvelous ingenuity. A few years ago these scorpions were common on the Florida Reef and were frequently killed in my own house at night. The pain resulting from the sting was about as disagreeable as that occasioned by a wasp. These scorpions were about three inches in length, but in Ceylon very much larger ones have been seen, and known to catch birds. The young scorpions are born alive and cling to the mother. The little book scorpion, the large whip scorpion, and the daddy longlegs, or harvestman, a harmless and sociable insect, are related to the true scorpions.

XX. THE SPIDERS

A LITTLE insect half as large as a grain of corn, finds itself on a limb high above ground and is desirous of reaching another, five feet away. It is not a jumper, at least it could not hope to cover this distance; neither has it wings. But it has a marvelous silk-manufacturing apparatus, known as spinnerets (Fig. 169), and elevating its abdomen it reels off a thread which the wind carries across the chasm where it lodges. Across the single cord the spider runs, the act being suggestive of the intelligence of these insects.

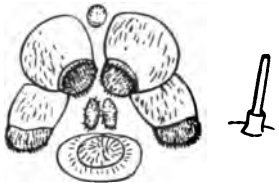


FIG. 169. — Spinnerets of a spider.

The common garden spider (Fig. 170), which may illustrate the group, is seen to differ very materially from the scorpion. The abdomen is not ringed or made up of segments, but is large and plump, and connected with the thorax by a delicate cord or pedicel.

The spiders, as we ·ve seen, have a spin- arrangement by ·ey form beauti-

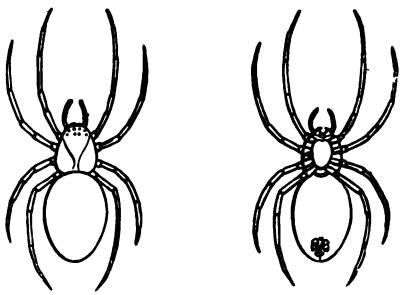


FIG. 170. — Garden spider, upper and lower surface.

ful webs or nets to capture prey. By this silken cord they can lower themselves from great heights. The single thread which supports them is made up of a number of minute threads (Fig. 171). The webs are formed in endless variety and with all the skill of a bridge maker, being guyed, supported, and braced in a manner which, if the work of man, would be said to be the result of endless study. They are perfect in their arrangement, and each web is a study in geometry, yet the spider builds it with the greatest rapidity, never hesitating in the making or repairing.

FIG. 171. — Structure of a spider's web.

By my door is a huge spider similar to the one shown in Figure 172. It has a beautiful web which covers a space

FIG. 172. — Spider and its web or trap.

two feet square, but the spider rarely occupies it. Near by it has a covering formed of a leaf of a fern which it has pulled down each side and fastened, forming a little room just the size of its body. Wondering how the spider would discover a victim caught in the web, I examined it carefully, and then placed a grasshopper in the web. Instantly the spider noted the disturbance, having what to all intents and purposes was a private telephone line. This was a single guy line leading from the center of the web to its retreat, where one of the spider's claws rested upon it, holding it, so that the slightest swaying of the web lifted its foot. When an insect became entangled, the spider darted at it, and by skillful manipulation of its hind pair of legs reeled off its silken cord and attached it to the victim at every point, in a short time literally binding it in a roll. If it was likely to escape, the spider would bite it, using its poison fang (Fig. 173), which paralyzed it. The biting mandibles (Fig. 174) are terrible weapons, from which there is no escape. The inner jaws (Fig. 175) are equally sharp and effective.

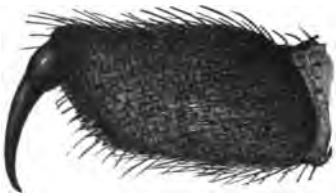


FIG. 173. — Highly magnified poison fang of spider.

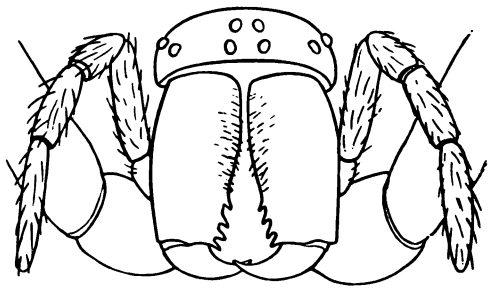


FIG. 174. — Biting mandibles of a spider.

The eyes of the spider are very brilliant, and in a bright light can be seen to gleam and glisten like points of steel or fire. They are minute dots, seen just above the mandibles.

FIG. 175. — Jaws of a spider.

The male and female spiders often present a very different appearance, the male being smaller. The spiders deposit eggs which are inclosed in silken balls or nests of various kinds, in which they remain until the young are hatched. Some are concealed in the web; others are placed underground; and some are perched upon a stalk resembling a plant.

There appears to be no limit to the uses to which the marvelous silk of spiders is put. Some spiders form balloons with which they sail away through the air. I have seen scores of these aëronauts in the air at one time. Another form constructs a raft of leaves bound together with silk. Some build nets for small game, as gnats. The silken cord made by others is so tough that it can be used as thread.

By partly destroying a web and suspending a black cloth behind the locality, the operations of the spider in building and repairing can be plainly seen. It is well to place the spinnerets beneath a microscope, under which they appear to be made up of many points. Touch one of these and a glutinous secretion adheres, which when stretched is seen to be silk, and each point provides a separate thread which joins with the others, producing one cable. The spinnerets are to some extent movable. They can be turned to the right or left, and wherever they touch, the

silk remains glued fast. This explains why the spider moves and works so quickly and accomplishes so much. The amount of silk secreted is astonishing, and some idea of it can be obtained by walking over the country in spring, early in the morning. On the slopes of the Sierra Madre, in the San Gabriel Valley, I have seen the surface of the ground for a great distance covered with webs which caught the rays of the sun as it rose, presenting a most beautiful appearance. This fabric covered hundreds of acres in a fairy maze of web, so many traps for unwary small fry of the insect world. With a small stick I have wound a large amount of silk from the spinnerets of a spider, there apparently being no diminution of the supply. Professor Burt Wilder wound from the large spider known as Nephila plumipes several miles of silk. Some spiders have long, slender legs and are rapid runners. Others, as Salticus, are very deliberate, but powerful leapers, jumping upon their prey like a cat. Perhaps the most remarkable leaping spider is one from Australia, called the flying Attus, having singular flaps or winglike extensions upon its sides. One of the spiders not only runs over the surface of the water readily, but spends a part of its time under the surface, carrying down a bubble of air for its supply of oxygen, the bubble acting as a diving bell.

The spiders are very solicitous of their young, placing every safeguard about them, and resenting any attack by a fierce rush. Several large spiders (Fig. 176) carry their young upon their backs. The little spiders are rubbed or scraped off when they become too great a burden. The spiders are natural hunters and trappers, and a volume could be written on their methods and adventures in run-

ning down prey. Once as I was crawling through the almost stifling brush of one of the Florida Keys I came to a little opening about five feet wide, across which was a large, conspicuous, and powerful web. In the center of this web clung a huge and most remarkable spider, colored a vivid yellow and black. I watched it for a few moments while resting, and then touched the web, whereupon the spider began to swing, by raising and depressing its body,

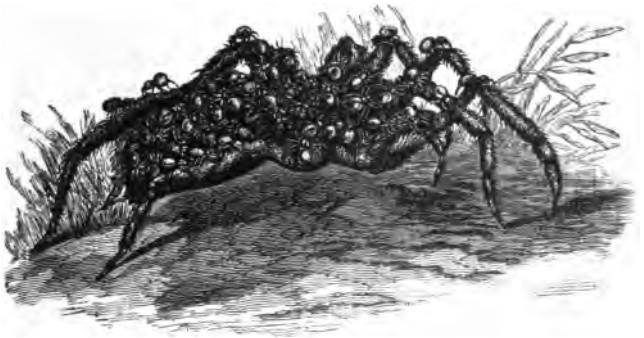


FIG. 176. — Spider with young upon its back.

increasing its speed rapidly, until I could with difficulty see it. A moment later it disappeared almost entirely before my eyes. For half a minute the spider kept up this motion, then it slowly came to a standstill, having demonstrated that it could easily disappear from any bird enemy without running away. I have seen the daddy longlegs perform the same feat in California.

The spiders which build webs, from plain geometrical traps to conelike affairs, are interesting; but the trapdoor spiders and those which dig burrows are among the wonderful artisans and engineers of the insect world. One of

the most perfect doors, in hinge, fit, beauty of interior, finish, and quality of its outward defense is built by a spider (Fig. 177). In the illustration, the den and its trapdoor is shown, and in Figure 178 a sectional view of the same is seen; but the door is never found open, the spring or hinge being so devised as to remain closed. I have found many of these dens in southern California sometimes a foot or more in length. The spider is not the large one shown in the cut, which is a tarantula, but is very much smaller, though a large spider. The genera, Cteniza and Nemesia, are best known for their cunning and skill as builders. The California spider begins its den when very small, and I have found many the size of goose quills, with door complete, in the vicinity of a large den.

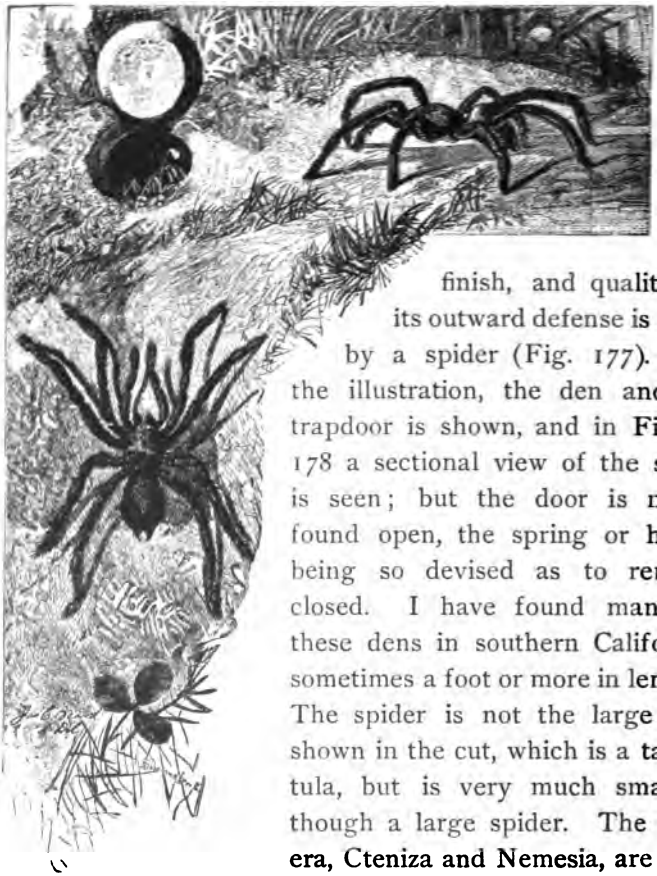


FIG. 177. — Tarantulas (*Mygale*) and the opening of a trapdoor den of another spider (*Cteniza*).

In forming the burrow the spider carries out the clay bit by bit, and when it reaches a point below the surface it begins to line the sides with a silken tapestry. The door is an upper extension of this lining. It is round, about the size of a silver quarter, or a little larger, and is formed of silk so woven and interwoven that it becomes a pad of seeming satin, which by continued manipulation is made to fit with marvelous perfection. The spring or hinge is so adjusted that the door always closes, and with a snap. The exterior of the door is covered with clay, and is made to simulate the surroundings so exactly that only the sharpest eye, and one skilled in the work, can distinguish it. In some of the European spiders of this kind the door is carefully covered with moss and plants. The work of building is done at night. The spiders feed at night, and in returning to the burrow they can lift the lid instantly, dart in, and turn about to seize the cushion or pad of the door with their fangs, and hold it so tightly by bracing back that some little strength is needed to force it. I have often lifted the door with the blade of my knife and seen the spider rush up and seize it. In all the doors little round holes can be seen where the mandibles or fangs hold. The spider can be caught by pouring water into the burrow and forcing it out. In the island of Timos there is a trapdoor spider which does not hunt, but combines the methods of other spiders. It comes out at night, fastens back its

FIG. 178. — Section of a den of trapdoor spider.

door by a thread, then builds a web near by and waits for its victims to become entangled.

The largest spiders are called tarantulas, though the term is applied to some forms not so large. They are hideous creatures, and are very common in southern California. They are five or six inches across the legs, and the body in some forms is as large as a small mouse, and is covered with reddish hair. They form deep burrows,

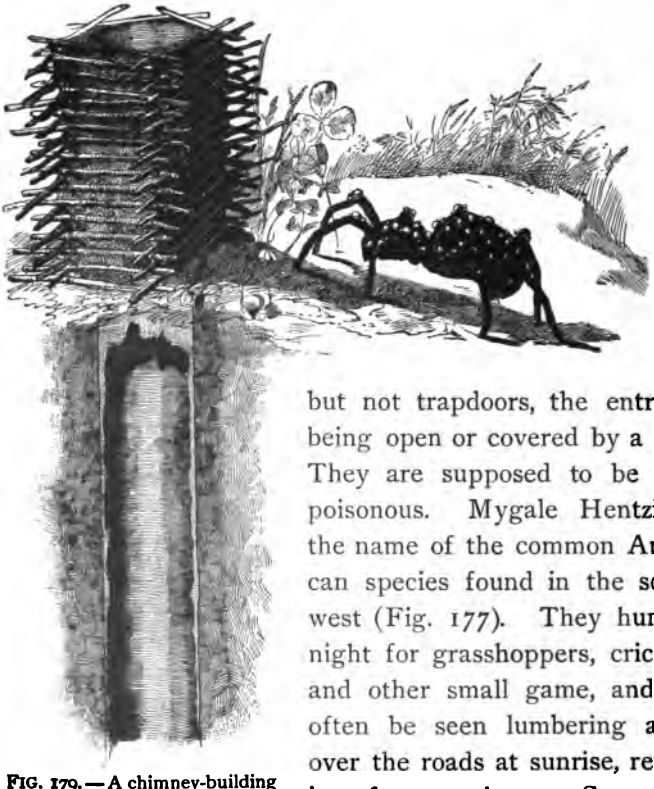


FIG. 179. — A chimney-building spider.

but not trapdoors, the entrance being open or covered by a web. They are supposed to be very poisonous. Mygale Hentzii is the name of the common American species found in the southwest (Fig. 177). They hunt at night for grasshoppers, crickets, and other small game, and can often be seen lumbering along over the roads at sunrise, returning from a hunt. Sometimes

these huge spiders migrate in a body, such a movement having been observed in southern California.

A South American species has been known to attack and capture small birds, though this may be considered rather the exception than the rule, their food consisting of large insects and small lizards. Of all the spiders, the Tarantula turricula (Fig. 179) is the most remarkable, as it not only makes a deep burrow, but erects above it a chimneylike structure with all the skill of a human workman. Indeed, the structure, in neatness and perfection of design, is far superior to many of the chimneys seen among the poorer classes of some countries. The spider lays the miniature timbers across with the precision and exactness of a skilled carpenter and after the manner of human log-cabin builders. The female carries her young upon her back, as shown in the illustration.

XXI. SOME SIX-LEGGED INSECTS

One of the great divisions into which the insects are divided relates to their possession of six legs (Fig. 180). This includes a marvelous array of creatures. Among them we find the singular little glacier flea (Fig. 181) and the springtail, a prodigious jumper (Fig. 182). The latter is found in damp places, and when touched will release a forked spring which is held in place by a hook, and this sends the insect flying into the air like an acrobat. These humble little creatures present a strange contrast to the lace-winged insects which are among the most beautiful of the tribe.

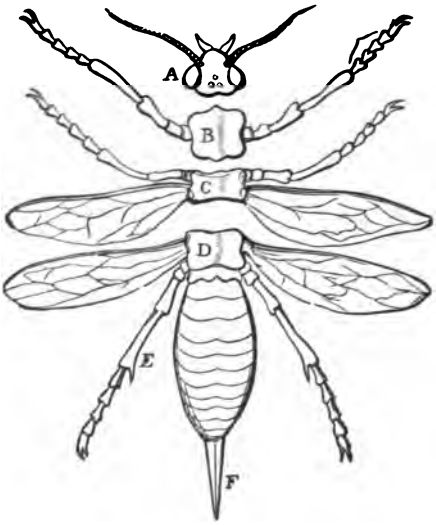


FIG. 180. — A six-legged insect.

The May flies (Fig. 183) are well known for the wonderful exhibitions they sometimes make, the air being filled with them, a joyous, beautiful throng, destined to live but a few hours. In South America they occur in such vast

numbers that they are collected and used as guano. The young pass through a strange change, having little resem-

FIG. 181. — Glacier flea.

blance to the parent, and live in the water, where they breathe by means of several plumelike gills.

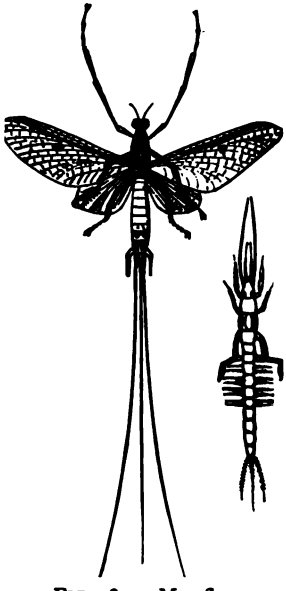


FIG. 183. — May fly.

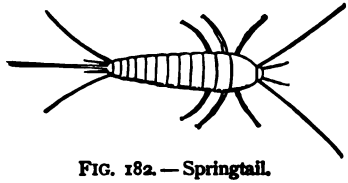


FIG. 182. — Springtail.

Among all the insects of the field and swamp none are more familiar than the dragon fly (Fig. 184), which children were once led to believe had a vicious habit of sewing up the eyes and mouth of any one; hence the name "darning needle." These insects are often beautiful, with their rich wings of glistening lace, four in number, their bodies gleaming in tints of bronze, blue, and black. The abdomen is long and slender, like a needle; the head is prominent and armed with powerful jaws; the eyes

are large and compound, with several single eyes as well. Some dragon flies are very small. Others are large, as those of the Malay Archipelago, where the natives trap them and use them for food. The dragon flies are hun-

FIG. 184. — Dragon fly.

ters, preying upon other insects which they capture on the wing, and large forms have been seen taking very young fishes from the water, swooping down upon them like hawks.

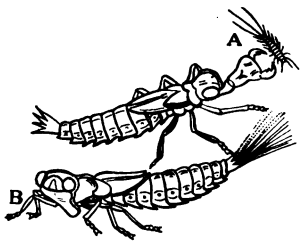


FIG. 185. — Larvæ of a dragon fly.

The development of the dragon fly is interesting from the fact that the young lives a long period in the water. The eggs are deposited in the water, hatching out into curiously shaped creatures (Fig. 185),

which are among the most ferocious of all the water insects. They pass two years in this form, preying upon other animals and even small fishes. The larva has a proboscis which ordinarily folds over the face and is called the mask (*B*), but when an insect approaches, this strange appliance with powerful jaws or hooks is shot out (*A*) with dire results. After the two years have passed the pupa, as it is called, climbs up a stem, leaves the water and casts its skin, appearing as a full-grown dragon fly ready for a life of rapine on land.

In many insects the habits of the young are much more interesting than those of the adults. Not far from my home, in the Arroyo Seco, which leads down from the Sierra Madre, are great deposits or beds of fine sand which I find often covered with little pits (Fig. 186). If a section is made (Fig. 187), it is found to be a perfect bowl almost half an inch in depth, as though a top had been pressed into the sand and taken out. If sand is rolled into the pit, something appears quickly at the bottom and mysteriously tosses it out; and if an ant topples over the

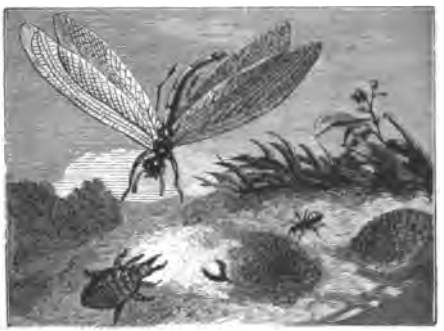


FIG. 186. — Ant lion, adult and larva.

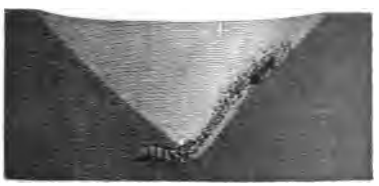


FIG. 187. — Section of trap of an ant lion.

edge and rolls down the sides, out comes a fierce pair of jaws and seizes it. If the ant escapes, the unknown creature, still concealed, hurls sand at it, endeavoring to bring it down, often with success. This singular creature is the larva or immature young of the ant lion — itself an attractive, large, lace-winged creature (Fig. 188), resembling a dragon fly. It lays its eggs in dry places. The young are wingless, big-jawed creatures, which for two years live the life of a trapper, each forming a pit and concealing itself beneath the sand at the bottom, the huge jaws being in the center. Ants are the game of this lion, and as they run along they often topple over the sides which, like those of a toboggan, are very slippery. Down the ant goes, its descent being accelerated by the lion which places sand upon its back, and bombards the unfortunate, so adding to its confusion that it rolls down and is seized by the jaws of the lion. At the end of the two years the lion surrounds itself with a ball of sand and silk, and in three weeks appears as the perfect insect.

FIG. 188. — Perfect form of ant lion.

Unless one is familiar with the eggs of the aphis lion (Fig. 189) he will never find them. They resemble minute plants growing on long stems, fastened to a leaf. These hatch out and become little creatures resembling the ant lion, with huge jaws.

But the most extraordinary changes and series of different individuals are found among the so-called white ants, which are really not ants at all, but among the most destructive of all known insects. The first white travelers in Africa reported the discovery of gigantic ant hills, some of which were twelve feet in height (Fig. 190) and one hundred feet in circumference. Equally large mounds have been found in Australia, large areas of country being dotted with these striking landmarks, among the most remarkable of all animal structures. These mounds are often as hard as rock, and hunters have sometimes escaped from the charges of wild animals by climbing upon them.

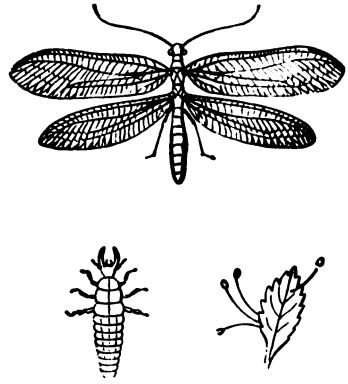


FIG. 189. — Aphis lion, larva and eggs.

They are the work of the so-called white ants. A section made through one of them, as seen in the illustration, shows the singular home of a remarkable community. There are really four kinds of "ants" here, all representing a different phase in the growth of the insect, and all performing a certain work. They are the female, the male, the worker, and the soldier; and there is a winged king. In their lives these insects have many features which resemble those of man. They have a king and queen, which at first have wings; later they lose their wings and the queen grows until she is thousands of times larger than the workers, and is kept in a special chamber in the

center of the pile. Here she is attended by the workers, small ants, who carry out the eggs which are laid by millions and placed in nurseries or small cemented cells, designed for the purpose. Sometimes the queen lays as

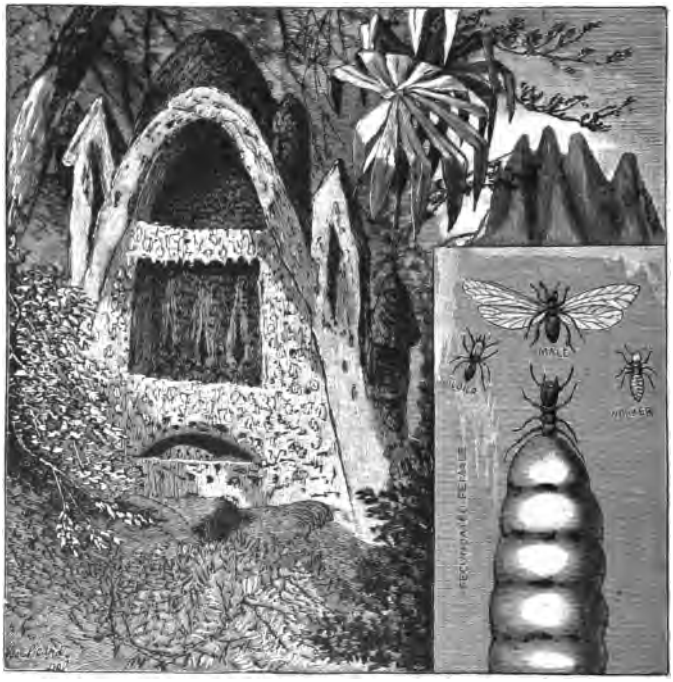


FIG. 190. — Hills of the white ant.

many as eight thousand eggs a day. An army of workers carries them off, builds new nurseries, and adds to the heap. If an enemy appears, the soldiers rush out. These have large heads and enormous jaws, and are well fitted by nature for the work they have to perform.

The cunning and intelligence of white ants are well dis-

played in their attacks upon houses. Having decided to enter a house, they begin to tunnel some distance away, and finally reach the corner post or some timber that enters the ground. With remarkable speed the workers enter this, hollowing it out, until it is nothing but a shell. They eat to the very surface, leaving only a faint ghost of a partition, and what appears to be a solid block is really so thin that a finger can be thrust through it. So clever are these little ant miners that they have been known to come up through the floor directly beneath the leg of a chair, and burrow and eat up through it, so completely devastating it that when the owner moved it the small hole in the floor appeared and the chair fell in pieces.

In the Isle of France a new building was ruined by these insects in a few months; and at Colombo a large house suddenly fell in over the heads of the occupants, the beams being crushed like egg shells. The work they accomplished in this way would hardly be credited were it not for the substantiated statements collected by the authorities in the countries where they are mostly found.

The so-called caddis worms (Fig. 191) are merely the larvæ of the caddis fly which incloses itself in a case that is often decorated in a singular way. The cases of a number of the worms placed together display a striking variety of designs. Some roll up leaves; others spin a silken thread from the mouth and bind pieces of leaves together, attaching other pieces to it.

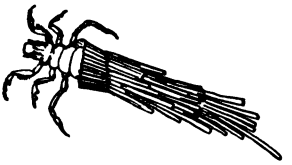


FIG. 191. — Caddis worm and case.

XXII. SOME MIMICS

ALL insects have a continual struggle for life. They constitute the food of many birds, and very few of the young escape these watchful creatures and attain mature life.

To enable the insects to escape, nature has given many a strange protective garb, which is called mimicry or a protective resemblance. Sometimes it is color, an insect mimicking a leaf in color; or again, the insect imitates a twig or leaf in shape, and so escapes attention. We find examples of this in many families, but particularly among the insects now under consideration. The mantis (Fig. 192) belongs to a group in which the insects resemble twigs in shape and color, and nothing could be more striking than these strange, slow-moving creatures. They have an uncanny, weird appearance, and look as though they might have been originally of wood. I have seen them in the tropics passing slowly along a limb, lifting one leg at a time, moving it with all the halting deliberation of an automaton; but when the mantis perceived me, it stopped just as it was, the foot that was in the air remaining as though it had been frozen in the act. Some are a vivid green, and in them the resemblance to twigs is very striking. I once encouraged a number to live in my preserves, where I watched and studied and often fed them. They would take a fly from my hand by a very rapid movement of the cruel fore hands or claws,

which were toothed. When food was scarce the insects would devour one another in the most deliberate fashion, then assume the quaint, supplicating position with claws up, from which the insect is called the praying mantis. My specimens deposited their eggs in a curious case about

FIG. 192. — The mantis.

an inch long, resembling a trilobite, which they attached to the fence and colored the exact hue of the latter. The fence was not painted, and varied in color, yet the nests always agreed more or less exactly with the shade or tint of the plank or base to which it was attached.

In South America is found a huge mantis so powerful that it captures birds by grasping them in its terrible claws. The insect is described by Burmeister as crouching on the limb, imitating it so closely that the bird approaches it without fear. In Java a beautiful pink mantis is so perfect in its mimicry of a pink orchid that insects alight upon it and are caught. A Philippine Island mantis is remarkable for its resemblance to a dried and withered leaf.

The chief characteristic of this insect is its cool, deliberate ferocity — devouring its mate with indifference, lunching calmly upon its young, while they are dining among themselves. When fighting they have the characteristics of the bulldog, with many times its endurance. A mantis will continue a combat even when part of its body is cut away. I have seen one deprived of all its legs cling to a limb with one claw and continue to reach for its foe with the other.

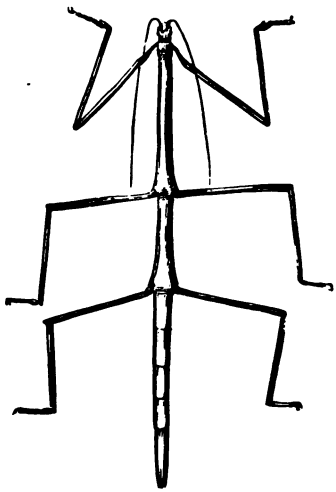


FIG. 193. — Walking stick.

Closely allied to the mantis, and even more remarkable as mimics, are the walking sticks (Phasma) (Fig. 193). I have kept them alive, and often have been unable to see them when I knew they were directly beneath my eyes, so remarkable is the mimicry. They have no biting claws, merely long antennæ, a long, sticklike body, and straight-

jointed, sticklike legs. Some are green. The most remarkable are those which seem to imitate dead wood. I have seen a walking stick that was a perfect imitation of a moss or lichen-covered twig, the body and legs of the insect being covered with peculiar growths. The largest walking stick I have seen was twelve inches in length, and one of the most perfect imitations of a green twig that could be imagined. This was from the Malay country, where they grow to a length of fourteen inches. They stretch out upon long tendrils, extending the limbs or holding them up, the *poseurs* of the insect world.

The walking leaves (Phyllium) (Fig. 194) are clever mimics, resembling leaves. Even the veins and midrib of the leaf are imitated, and the insect, when crouching on a limb, is a virtual leaf, so far as appearance goes, the disguise being absolutely perfect. Some resemble green leaves; others dried and withered specimens. Even the legs of these insects are supplied with a singular growth. Most of these strange mimics are found clinging to trees; but one common in Brazil spends most of the time during the day under water in streams, where it clings to the pebbles. In Nicaragua there are several species that resemble leaves in all stages of decay. The movements of some of these insects resemble those of leaves. I saw one in the Sierra Madre range come down from a tall sycamore, and supposed it a leaf, as it dropped slowly, zigzagging down. I should not have discovered the mistake had not my dog recognized it.

FIG. 194.—Walking leaf.

XXIII. THE GRASSHOPPERS AND LOCUSTS

THESE forms may be considered the musicians of the insect world. None of the insects can produce vocal sounds, that is, they have no voice, but they have certain appliances which enable them to produce sounds which can be heard a long distance. On hot days in summer is heard the constant and shrill zee-zeeing of the locust, while countless varieties lend their aid in producing a volume of sound.

FIG. 195. — A grasshopper.

The "instruments" in the locust are (Fig. 196) minute teeth, arranged along the thighs; these are rubbed against the fore wings, producing the remarkable sounds. The locusts are commonly called grasshoppers. They have two pairs of net-veined wings, and hind legs adapted for leaping, by which they send themselves sprawling through the air, almost invariably using this method of escape instead of unfolding their delicate wings. All are mimics. The common ground locust resembles the dusty road and the dried foliage which it affects. Others, which live on plants, are a vivid green. Some which I find in my garden resemble closely the tender shoots of the passion vine, upon which they feed.

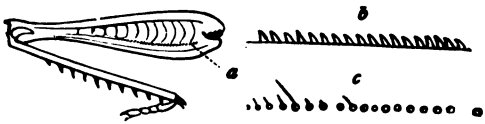


FIG. 196. — Musical instruments of the locust: *a*, leg; *b*, *c*, teeth, enlarged.

The locusts (Acridiidæ) have short antennæ, large glassy eyes, and ears at the base of the abdomen. The female is provided with an appliance called the ovipositor, four sharp points with which the grasshopper digs holes in the ground; later these are used as a guide or funnel for introducing the eggs into the burrow. The mouth is supplied with parts adapted to biting. When a grasshopper (Fig. 195) is caught it exudes a peculiar fluid resembling molasses, a secretion of the salivary glands. The eggs are deposited in masses from sixty to one hundred. The young resemble the parent, but at first have no wings. The grasshopper in making its metamorphosis, or change from one stage to another, casts its skin in a manner calling to mind the crabs; in a word, it molts several times (Fig. 197). In accomplishing this, it often climbs a spear of grass and there shuffles out of its old skin and jumps away, leaving the hollow skin clinging to the grass.

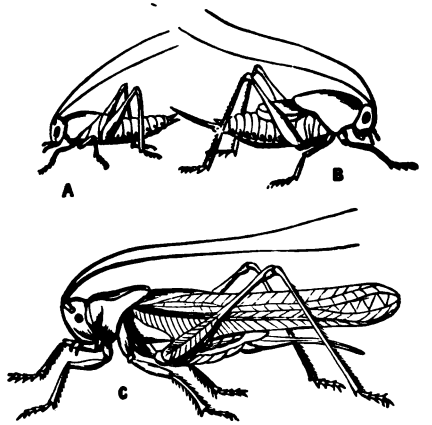


FIG. 197. — A grasshopper and young at different stages: *A*, larva; *B*, pupa; *C*, adult.

At times they appear in vast numbers, and in clouds rise into the air, so that from a distance they might be taken for smoke or a tornado. This cloud is made up of starving locusts which devastate the countries they infest. They alight upon a wheat field, and an hour later hundreds of acres appear as though a fire had swept over

the ground. Every spear of grass, every leaf, has been devoured by this insatiate throng, which can not be destroyed or even checked. In Africa swarms have been swept by the wind out over the ocean, to be washed in in such vast numbers that they formed a line fifty miles long and three or four feet high alongshore, creating an odor which drove people from that region. Jægar, the naturalist, rode through a swarm in Russia for four hundred miles where they were two feet deep. The entire country was devastated by this band of locusts, and tens of thousands of human beings were threatened with starvation. The government troops were ordered to the place and warfare declared against the locusts, the soldiers being armed with shovels instead of guns. A line of thirty thousand men moved slowly forward, covering the insects with earth or digging them under, while in various localities huge fires were built to burn the ground and destroy the eggs. Despite this, thirty thousand people starved to death, the direct result of their raids. Almost every portion of the world away from the poles has been threatened by these raiders. There are many references in the Bible to these insects, and their ravages have been carried on from the earliest times known to man. In America the Rocky Mountain locust is the most destructive, and many of the Western states have been ravaged by them.

"Onward they came, a dark, continuous cloud of congregated myriads, numberless.
The rushing of whose wings was as the sound of a broad river, headlong in its course.
Plunged from a mountain summit, or the roar of a wild ocean, as the autumn storm,
Shattering its billows on a shore of rocks." — SOUTHEY.

Some years ago a flock settled in Colorado Springs, the streets and roofs being covered with them, so that they were swept and shoveled about like snow. Some American swarms have been traced for several hundred miles, and settling on railroads, have stopped the trains by making the tracks slippery. Alighting in a cornfield the rustling sound of their depredation can be heard for some distance; and when they rise, a fire might have swept over the fields, so far as appearances go. The swarm, a black, portentous cloud, sweeps on, flying at a rate of thirty miles an hour to reach some new field, where they dig burrows with their curious ovipositors, and deposit their eggs by millions. Then they move on, leaving an unborn swarm to develop and later constitute another army to spread devastation abroad in the land.

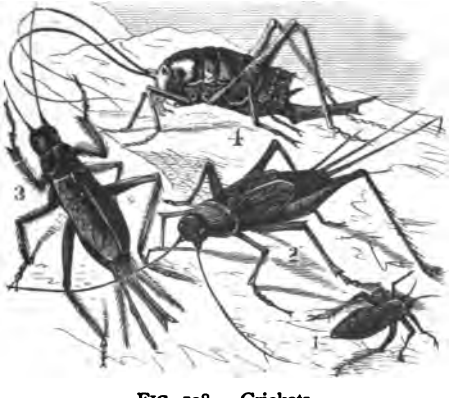


FIG. 198. — Crickets.

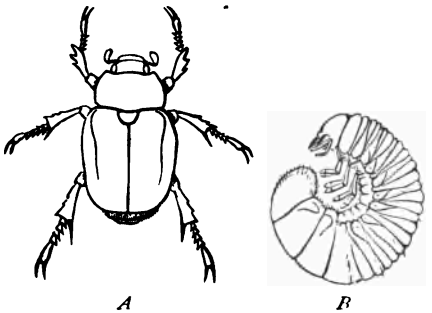
The crickets (Fig. 198) are familiar forms with cylindrical bodies and large heads placed vertically, the ovipositor often being as large as the entire body. The female often deposits three hundred eggs in the ground. The note of the cricket is produced by the male, and is a decidedly musical chirp, varying in the different kinds. The close observer may easily find the cave house of the little singer that is often seen sitting at the entrance,

singing, not at the top of its voice, but with the full force of its wings, the sound being produced by using the fore wings, as bows and the hind wings as fiddles, and sawing with great rapidity.

The crickets are found in the greatest variety. Some live in the ground, others affect houses, and in the tropics beautiful tree crickets are found. The snowy tree cricket has a peculiar note, *te-reat, te-reat, te-reat.* The broad-winged tree cricket has a call which resembles a dog whistle. Another has a piping note resembling the thrilling musical sound made by rubbing the edge of a glass with one's finger. The singular cave cricket is wingless, and has antennæ several times the length of its body. The Western cricket does great damage to the crops of the farmer, and when bands are seen marching over the country, ditches are often dug into which the crickets plunge, where, in default of food, they begin to devour one another. The cry of this cricket is harsh and disagreeable, the "musical instrument" being on the dorsum or back of the shield which seems to cover the fore part of its back. The curious mole cricket, which burrows underground and is provided with enormous jaws, is a menace to the gardener. In the outer Florida Keys I found that it was almost impossible to rear plants, so plentiful and ravenous were these fierce root eaters.

XXIV. THE BEETLES

THE beetles (Fig. 199) are insects having their fore wings thickened to constitute sheaths or covers for the lower pair, used in flight. Their mouths are adapted for biting, and they pass through a complete metamorphosis. There are about ninety thousand species, ranging from minute creatures to huge, lumbering goliaths. When walking the beetle presents a trim appearance, enveloped in a gleaming armor of the highest polish, and often ablaze with metallic tints, but when it flies the elytra, or wing covers, are thrown up, and a pair of soft, silken wings flutter out, stiffen, and bear the beetle away.



A B

FIG. 199. — A typical beetle (*Cotalpa*): *A*, imago; *B*, larva.

The head of the beetle is small and adapted for biting (Fig. 200); the digestive apparatus is simple. The most noticeable feature of many are the antennæ (Fig. 201), which often are very long and ornamental. The eyes are compound. The legs are strong and powerful. The beetles

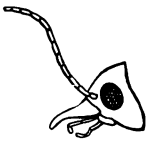


FIG. 200. — Head of a beetle.

spend little time in flying, many being flesh eaters and continually searching for game under refuse and in dark places. They lay eggs which are deposited in the ground, or in special cavities made in wood, which hatch into larvæ (Fig. 202). In the tiger beetle the larvæ resemble white worms. In the rose beetle they look like grubs. These in time change to helpless pupæ.

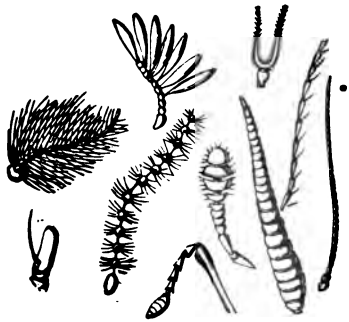


FIG. 201. — Antennæ of beetles.

The June bug, the beetle which dashes into rooms, blindly charging lights of all kinds, is a familiar example. Its larva is white and very destructive. On my lawn in California the Bermuda grass often turns white, and sections a foot square can be lifted, having been cut off from the roots by this destructive larva of the June bug, which during this stage of its existence lives underground, eating roots and plants of various kinds. For two years this beetle (Fig. 203) lives a sub-

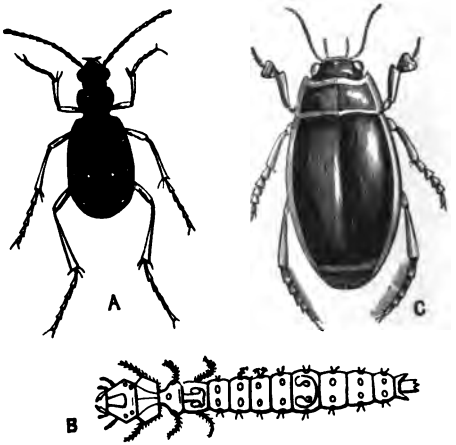


FIG. 202. — Beetle and young: *A*, tiger beetle; *B*, larva of same, enlarged; *C*, water beetle.

terranean, marauding life, growing and shedding its skin. It is often considered a complete animal, but at the end of this period it changes into what is called the pupa stage, which does not move; the pupæ are white, soft, helpless creatures which are found around the roots of rose bushes in great number, and which are so appreciated by mocking birds that they and the blackbirds invariably follow me about the garden when I am overturning the soil with the trowel. Finally the pupa changes into the perfect insect.

FIG. 203. — June bug, showing wings and wing covers.

The larvæ of some of the spring beetles remain in the "grub" stage five years, and are known as wire worms, doing a vast amount of damage.

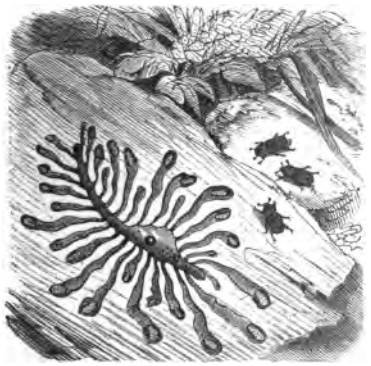


FIG. 204. — Bark-boring beetle.

The girdler beetle bores holes in tender limbs of the hickory, then systematically girdles the limb below the eggs, so that by the time the young hatch they have soft, dead wood to feed upon. The bark borer (Fig. 204) penetrates the bark of trees, and cuts winding tunnels here and there, in which are placed its eggs. Among the most attractive of the beetles are the carnivorous sexton beetles. They find dead bodies with

all the skill of a vulture, burrow beneath them and deposit their eggs within the body, where the young feed. The work these beetles accomplish in destroying animals and even burying them renders them valuable scavengers. Among the destructive beetles are the buffalo bugs (Fig. 205), which have been introduced from Europe; the larva of these is a strange, fuzzy little creature (*a*).

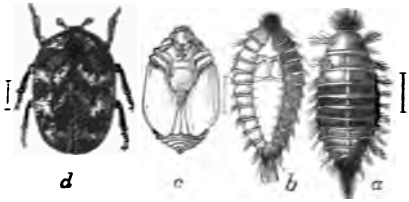


FIG. 205. — Buffalo bug and various stages of young.

The weevils (Fig. 206) are the bane of the dweller in the tropics. They infest bread, cake, and flour and meal of every kind. Perhaps the most dreaded by the Northern farmer is the potato bug (Fig. 207), which plays havoc with potatoes, often ruining the entire crop, the vines being covered by the soft and disagreeable larva, more like a worm than anything else. The diving beetle is an interesting insect, being a flier and a swimmer. Its hind legs are fringed and adapted for swimming. On the fore limb is a sucker, or several, by which the beetle can attach itself to any object. The larva is a ferocious creature, armed with a pair of fierce jaws, with which it attacks small fishes, frogs, tadpoles, and game very much larger than itself.

FIG. 206. — The weevil.

FIG. 207. — Potato bug, eggs and young.

XXV. THE BUGS

THE bugs are easily recognized. They have the mouth parts arranged as a sucking beak or proboscis. The chinch

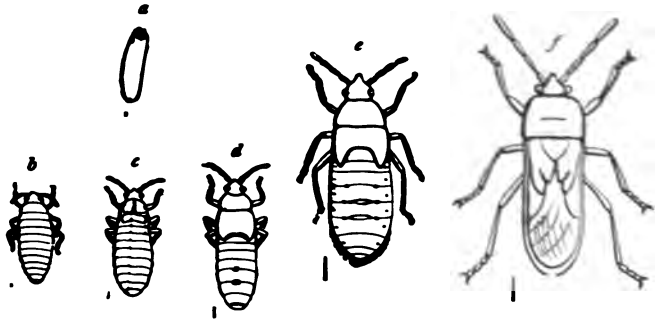


FIG. 208. — Chinch bug, egg and various stages of the young.

bug (Fig. 208), the squash bug (Fig. 209), the seventeen-year cicada, or locust (Fig. 210), and the bean aphis (Fig. 211) are well-known examples. They represent a group dreaded for many reasons; many are parasites on man and beast, while many others destroy crops of various kinds.

FIG. 209. — Squash bug.

In nearly all fresh-water ponds and pools curious flat, long-legged creatures (Fig. 212) are seen darting over the surface, being perfectly at home. They are water boatmen, and one species (Fig. 213) is found far out at sea.

In passing in review the various insects the peculiar transformations through which they pass are noticed; some long, some short, some partial, and many complete. In the cicada, or seventeen-year locust, or harvest fly, we have an instance

FIG. 210.—Cicada.

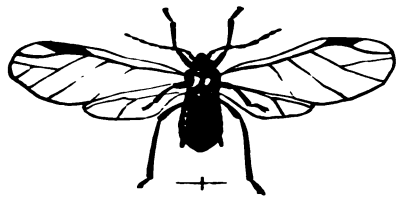


FIG. 211.—Bean aphis.

of one of the strangest examples of slow development known. The cicada is a wedge-shaped insect having some resemblance to a huge fly. At the base of the abdomen is a drumlike organ by which it makes a shrill "zeeing" sound

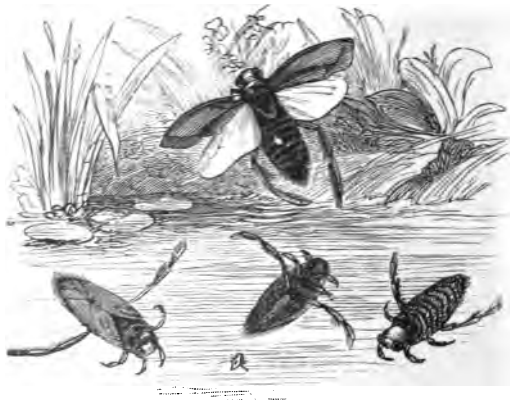


FIG. 212.—Water boatmen.

which, when thousands are joined in concert, produces a remarkable sound audible for a long distance. I have heard it half a mile with the wind, and by following it up found a grove filled with insects producing a roar of sounds, while, clinging to the trees and branches, were thousands of empty skins from which the cicadas had escaped. The cicada deposits three or four hundred eggs in holes on the twigs or bark of the oak. They hatch very promptly in six weeks or so, and we might conclude that the young cicadas would soon appear. But seventeen long years of life underground are now required before the pupa crawls upward, molts, and appears as an adult cicada. It has spent all these years as an almost helpless creature, resembling the mole cricket, subsisting by sucking the juices from the roots of plants, waiting for the ending of its imprisonment.

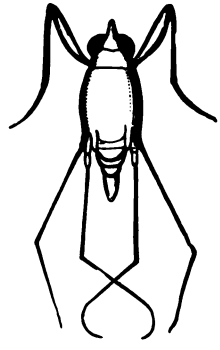


FIG. 213. — Halobates, a bug that goes to sea.

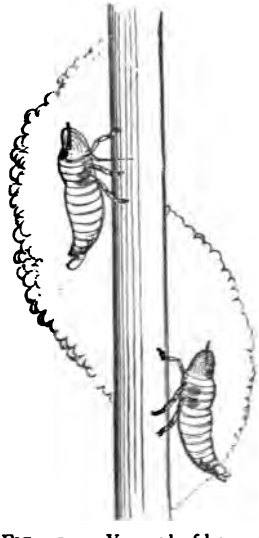


FIG. 214. — Young leaf hopper and its bubbles.

On many plants the stroller through the garden will observe bits of white froth, like soap suds, and few persons, were they not in the secret, would believe that the froth is an especially devised medium for the little leaf hopper (Fig. 214). The

adult insect is a curious little creature found among the grasses in spring. The young require moisture to enable them to attain their full development, and when hatched they climb up stalks of grass and pierce them with their beaklike proboscis and gorge themselves with the juices. The insect now exudes a foamy secretion which bubbles up about it, in time entirely surrounding itself in a mass of moisture. The insect converts this into air globules by pushing its tail above the mass (*a*) and seizing air in its claspers, which it passes beneath it to the spiracle or breathing pore. In this way it breathes and also fills the section about it with air. There the animal passes the time until it is ready to change, when it escapes and becomes a perfect leaf hopper. The famous cochineal insects (Fig. 215) belong to this group. They are minute creatures which live upon certain cacti in the tropics. When collected they form the celebrated dye. Another form produces a valuable wax.

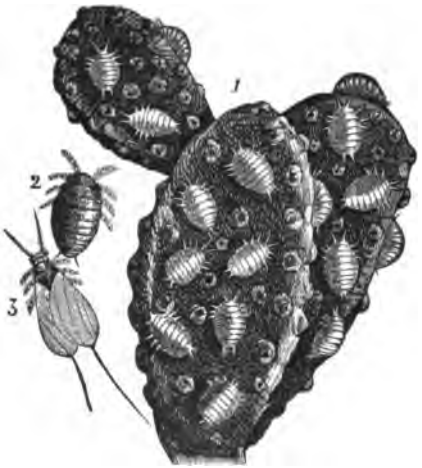


FIG. 215. — Cochineal insect.

Who has not found his rose bushes swarming with minute green bodies, the Aphidæ? Brush them off at night and in a few hours as many more are seen, due to the marvelous rapidity of their increase. The eggs are

laid in the autumn, and hatch in the early spring, the young then appearing as wingless little creatures which in turn produce not eggs but winged or wingless Aphidæ (Fig. 216). These appear in such numbers and so quickly that in a single summer a pair of plant lice will produce one quintillion of young ones. Can we wonder that it is difficult to keep the rose bushes free from such a swarm? The story of the development of these insects is but merely touched upon, but it is among the most remarkable of all the strange and unexplainable transformations we find in animal life.

FIG. 216. — Aphis.

Here we may glance at the countless scaly insects which infest fruit of various kinds. The black, red, and cottony scale are common in California, and have to be fought with all the cunning and intelligence that man can invoke. In 1886 the orange groves of southern California were almost ruined by the cottony scale. I have seen trees that looked as though the limbs were covered with snow. But an enemy of the scale, a little spotted lady bug, was imported from Australia, and in a few months the scale had disappeared. The black and red scale and several others are pests which devastate the groves, stopping the growth of the trees and operating against the fruit grower, who is obliged to spray the trees with poisonous washes to destroy them.

XXVI. FLIES AND MOSQUITOES

The flies and mosquitoes are among the greatest pests and dangers to man. Both are conveyers of disease, and

FIG. 217. — A fly, natural size and magnified.

the former, as an agent of destruction, deposits its eggs in meat of all kinds, making it impossible to keep meat in some countries. On the other hand, it should be remembered that the flies are valuable scavengers, hastening the destruction of dead matter which might contaminate the air.

FIG. 218. — Tongue of a fly.

The flies (Fig. 217) are two-winged insects with mouth parts adapted for lapping (Fig. 218) or sucking. Under the microscope these organs often appear to be composed of needlelike bristles, forming a proboscis protected by a scabbard or sheath. In some flies this weapon is many times as long as the body. The head is well separated from the body, and movable. The eyes are compound and simple, made up of many facets (Fig 219). The wings are gauzelike, often beautiful, and when the fly is in motion, they move in a figure eight, making, it is estimated, 19,800 revolutions a minute. The feet (Fig. 202)

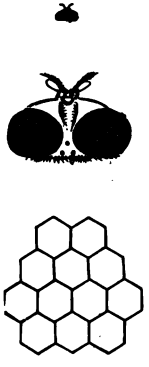


FIG. 219. — Eyes of a fly.

enable it to cling to the smoothest surfaces with ease. The little pads are extremely irritating at times when the fly walks over the flesh, tapping here and there with its soft tongue, in which all parts except the labium are rudimentary. The latter has a broad tip for licking or lapping. The flies breathe by spiracles, and are among the most active of all insects, and the bravest, attacking man and beast, and refusing to be driven off, despite the most active and spirited defense.

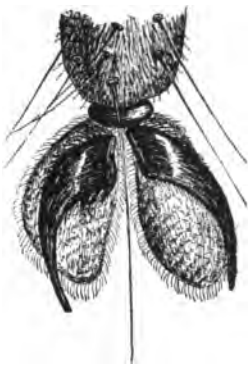


FIG. 220. — Foot of a fly.

The development of the house fly is a familiar process. The eggs of the flesh fly, as an example (Fig. 221), are small, white objects which hatch into maggots. These change gradually, finally becoming pupæ, then assuming the adult form. The bluebottle fly

FIG. 221. — Flesh fly, eggs and young in various stages of development.

(Fig. 222) is one of the best known. The house fly is found in greatest numbers near stables, as there, in the piles of refuse, the eggs are deposited, hatching in twenty-four hours. The young appear as fleshy, soft, footless worms or maggots, which are ravenous, and live upon the most fœtid matter for two weeks, when they change into a pupa, a barrel-shaped, cocoonlike form. For two weeks

this remains motionless, when out of it breaks the perfect house fly, soon to deposit its eggs and help to produce the tens of millions of flies which swarm wherever human beings are found.

FIG. 222. — Bluebottle fly and young.

Among the many species of flies some are bloodsuckers, as the horse flies. The robber flies are the hawks of the race, carrying off other insects, even large dragon flies. The many species of horse flies attack horses and cattle, and the animals are often driven to a frenzy by their approach. An entire herd will recognize the approach of these insects and stampede. Many of the flies deposit their eggs upon the hairs or nostrils of horses. Flies exist in countless varieties, from harmless creatures to some in Africa which are deadly to cattle and horses; from the ordinary fly whose larva lives in cheese to others which thrive in alcohol and wine. In California the larva of one species is found in Lake Mono, where no other animal can live. Hundreds of bushels of them are sometimes washed upon the beaches, constituting a favorite food for the Indians.

The warfare declared against mosquitoes in America, suggested by Dr. Howard, has attracted widespread attention to these insects, which have rendered many localities absolutely uninhabitable. A Florida physician informed me that in a certain locality horses had been killed by these insatiate bloodsuckers, which are now known to be the carriers of the germs of yellow fever. Over almost every

pond or pool in summer they may be seen in countless numbers, filling the air with their disagreeable music.

FIG. 223.— Proboscis of a mosquito.

The proboscis, or sucking weapon, of the mosquito (Fig. 223) is an innocent-appearing object when closed; but when the sheath is open it displays a series of scimeter and saw-tooth daggers (Fig. 224), which fully explains the torture of the mosquito bite or that of the gnat which crawls up one's sleeve (Fig. 225). In all these extraordinary weapons we find the same organs, the labium, labrum, and others, but with greater or less development, according to the nature of the insect.

FIG. 224. — Proboscis of a mosquito open.

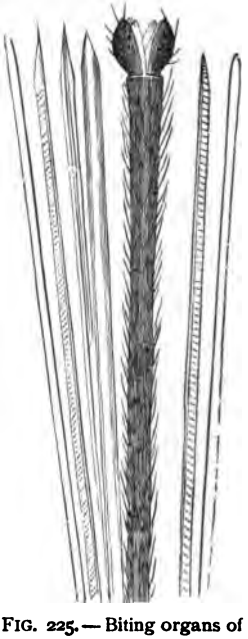


FIG. 225.— Biting organs of a gnat.

It is the female mosquito which occasions all the trouble and renders mankind miserable in some of the otherwise most delightful resorts. On the Florida Keys I always

had a mosquito bar overhead, not merely over the bed but suspended from the ceiling in midday. Even then these pests would force their way through the meshes.

FIG. 226. — Development of the mosquito.

The development of the mosquito is interesting (Fig. 226). The eggs are deposited as a boat-shaped mass on the surface of the water, where they drift about for several days. The larvæ appear as wigglers float-

ing in the water, tail upward, and breathing through a tube at the tip of the abdomen which is projected above the water for the purpose. After a while the head grows larger, and several changes ensue. Then the pupa finally appears. This rises to the surface, and out bursts a full-fledged mosquito which, like a man in a canoe, balances itself while its wings dry. A few hours before it was

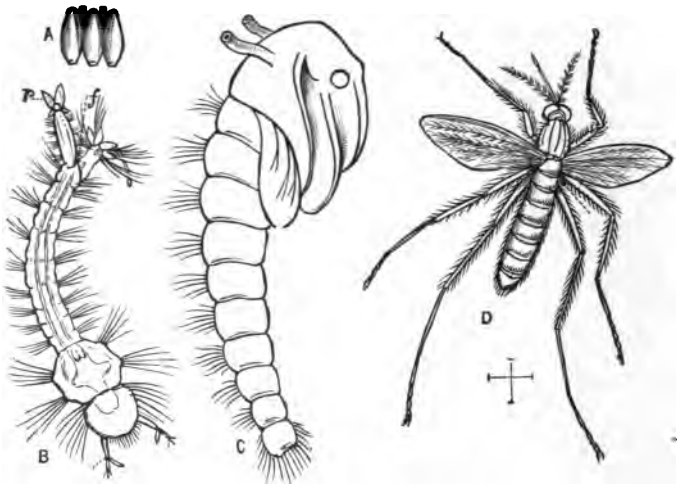


FIG. 227. — The gnat (*Culex*) and its development from the egg: *A*, egg; *B*, larva; *C*, pupa; *D*, adult.

entirely dependent upon the water and swimming in it, but now it appears to be fearful of overturning the frail craft and falling in where it would surely drown. If all goes well, it soon tries its wings and goes buzzing away. The devastation caused by the armed and bewhiskered mosquito is not generally known. Doubtless thousands have lost their lives from this unsuspected cause.

The common gnat (Fig. 227) has habits similar to those of the mosquito. They are often seen floating in the air in great swarms or bands, rising and forming as though in some mystic dance.

Closely allied to these forms are the fleas (Fig. 228), which are at once interesting and irritating. They are

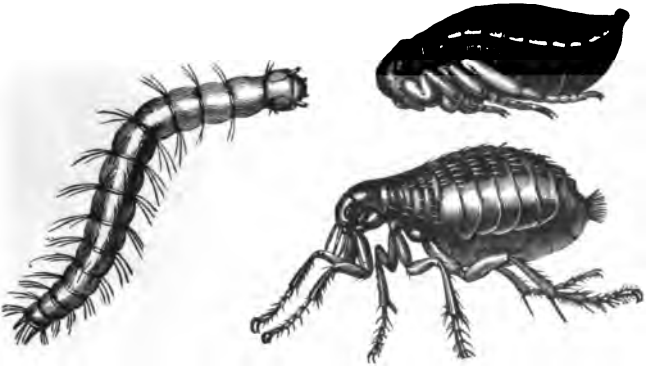


FIG. 228. — The flea and its development.

wingless, and have two simple eyes. The larva resembles a small caterpillar. It attains its growth in twelve days, then enters a small cocoon, which it weaves. There it remains for sixteen days, when it breaks forth a full-grown flea. Of all insects the fleas are the most amenable to instruction. Some years ago a flea circus was one of the attractions of New York, where, by looking through a magnifying glass, one could see fleas dragging chariots with other fleas dressed as cavaliers sitting on the seats. Many other seemingly impossible feats were exhibited.

XXVII. THE BUTTERFLIES AND MOTHS

Of all the insects the butterflies (Fig. 229) are the most beautiful. Nature has arrayed them in coats of many colors. Every tint and every possible shade of color, includ-

FIG. 229. — A butterfly.

ing metallic, is found among them. In some of the South American forests they are of gigantic size, a blaze of iridescent blue, as though formed of the most delicate flakes of that beautiful mineral labradorite.

The butterflies add to the beauty of nature. Among the trees they congregate, forming dashes of color, red, blue, green, and golden yellow. They vie with the flowers

in their splendors; besides being ornamental they accomplish a great work in carrying pollen from flower to flower and from plant to plant. They have small heads (Fig. 230), short antennæ, and four beautiful wings which are covered with minute scales. Each of the latter when

FIG. 230. — Head of a moth.

FIG. 231. — Mouth parts of a butterfly.

examined under a microscope becomes a resplendent object, glistening like the plate of some gorgeous armor. The mouth parts are adapted for sucking, and are coiled up when not in use (Fig. 231). They consist of two tubular or hollow threads.

The ordinary caterpillar is the larva of the butterfly. The eggs are deposited on leaves and various places, and soon hatch into caterpillars (Fig. 232). These lead a predatory life for some time, doing a vast amount of damage, almost every plant having its peculiar pest. Some affect one tree, some another. The famous elm trees of many of the New England cities have more than once

been threatened by these larvæ. They shed their coats several times. The caterpillar finally merges into the chrysalis, from which it escapes as the perfect insect. All of these changes can easily be observed by keeping a caterpillar under continuous observation. The butterflies have well-developed legs, but they rarely use them for locomotion, preferring to fly from flower to flower.

FIG. 232. — Butterfly and young.

The tortoise-shell butterfly is a familiar form (Fig. 233), its marvelous colors resembling this shell. Some have an under covering of pure silver. Another conspicuous form is the white butterfly (Fig. 234), which, as its name suggests, is pure white, with several black spots.

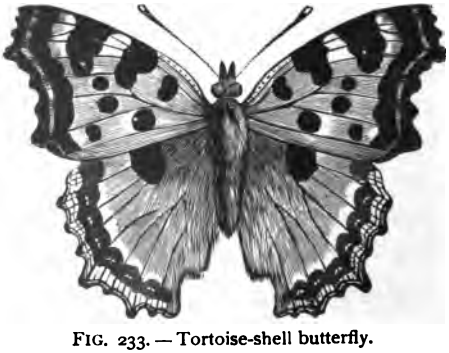


FIG. 233. — Tortoise-shell butterfly.

When the butterfly is at rest its wings are held aloft, and many are so colored that in this position the wing resembles a leaf and the animal escapes observation. A marvelous example of this protective mimicry is observed in the East Indian butterfly, Kallima (Fig. 235). The wings have a little projection which resembles a stem from which a dark mark resembling a midrib extends. When the butterfly alights, this seeming stem, as shown in the illustration, appears to join to the branch, and the resemblance to a leaf is so perfect that the most careful observer is often deceived. Other butterflies observed by Wallace mimicked dry oak leaves and dead leaves of various kinds. All the spots and colors of decay were imitated in their wings. Other Indian forms resemble fungus, and utterly disappear as they alight upon it. No more attractive butterfly is seen than the finely marked Vanessa, the peacock butterfly (Fig. 236), which has beautiful peacock marks upon its wings in vivid blue.

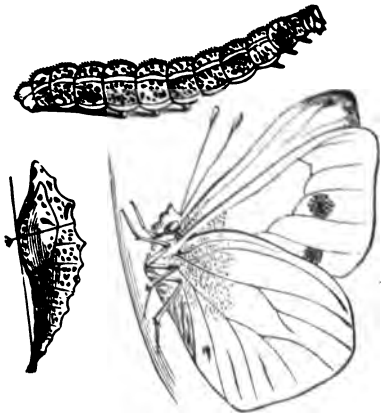


FIG. 234. — White butterfly and young.

In southern California, almost every spring, there is a migration of butterflies from the south northward along the Sierra Madre. I have watched them for hours, numbers being seen over a given spot every moment. By writing to postmasters and other persons in different sec-

tions, I found that the migrating band was two hundred miles long and from ten to twenty miles wide. Doubtless

FIG. 235. — A butterfly which resembles a leaf.

this was but a fraction of its actual extent, it being made up, in reality, of millions of yellow butterflies. Darwin saw such a migration in South America. Their pathway

was several miles in width, they filled the air like a yellow cloud, and were several hours passing a given point. Vessels out at sea have met with similar flocks blown away from the shore.

FIG. 236. — Peacock butterfly.

The butterflies are included in the Lepidoptera, and are the day-flying forms. There are many other insects equally beautiful, in more subdued tints, which are night flyers. These are

FIG. 237. — Silkworm moth.

the moths (Fig. 237), which are slow of flight, ponderous, and have extraordinary tongues for sucking the juices

from the flowers. They can be distinguished from the butterflies by their feathered antennæ. One of the best known for its ravages is the dwarf moth, the worm of which plays such havoc among woolens. The cankerworm moth is equally a pest among valuable shade trees. Another familiar form is the hawk moth (Fig. 238), which so resembles a humming bird in appearance and

FIG. 238. — Hawk moth, a rapid flyer.

motion that it is almost impossible to distinguish between the two, the moth being one of the most active, poising over flowers and inserting its enormous tongue to secure the sweets there concealed. A showy moth is the huge Attacus, its larva being especially large and voracious.

The moths display as great a variety in their shapes, colors, and sizes as the butterflies. The death's-head moth (Fig. 239) is perhaps as startling as any, bearing on its back a well-defined figure of a skull. The most valuable

moth to man is the silkworm moth, the wings of which have a spread of six inches and are a brilliant ochre yellow, fawn, or mouse color, marked with striking peacock-like eyes. They deposit eggs, but the development of the caterpillar is somewhat different from that of the butterfly

FIG. 239. — Death's-head moth.

larva. The latter passes its pupa stage as an unprotected chrysalis attached to some object by the tail (Fig. 240), but the caterpillar of the moth secretes silk from a gland in its head, and with this forms about itself a cocoon. This is unwound by machinery and woven into the valuable silk of commerce. The silk industry brings to the weavers

of the United States alone an annual sum amounting to about $30,000,000. The silkworm can easily be kept and all its changes watched, and many persons are interested in rearing the worms. The time required by the worm to form its silk cocoon varies with the locality. Thus in France it will complete it in four days, while in England forty or more days are necessary. About two hundred cocoons weigh a pound.

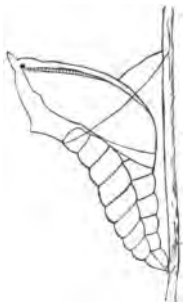


FIG. 240. — Pupa of butterfly.

Silkworm moths are ravenous eaters, living principally on mulberry leaves. They show much intelligence in forming their cocoons. Thus a South American moth (Fig. 241) forms a basketlike structure which it suspends from some limb. The cradle swings in the wind like a seed pod, more than anything else, and would never be suspected as inclosing a living creature. Many of the moths, by some remarkable instinct, deposit their eggs where the young will find an immediate supply of food. This care for their young is the cause of a vast amount of damage

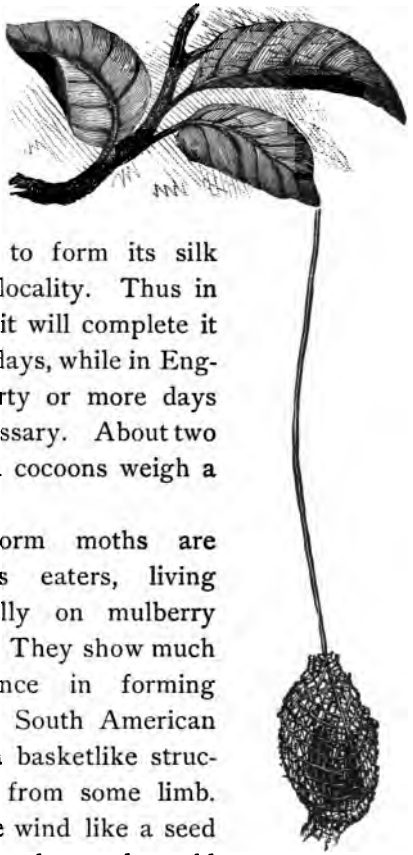


FIG. 241. — Basketlike cocoon of a South American moth.

among fruit trees. The fruit moth, as an example, deposits its eggs in fruit; the caterpillar penetrates it and devours the interior, thousands of bushels of apples being destroyed yearly in this way, not to speak of other fruits.

FIG. 242. — Tent moth, caterpillar and cocoon.

One of the best known of the moths is the tent moth (Fig. 242), the larva of which forms a tentlike web for its protection in the trees it affects. A richly tinted flyer is known as the goat moth (Fig. 243), the caterpillar being a large and beautiful creature.

FIG. 243. — Goat moth.

XXVIII. THE ANTS

If the question should be propounded which next to man is the most intelligent of animals, the reply might be, the ants; for after a careful study of all the ways and habits of these small insects, it will be very evident that the lives of many are conducted with more method than the lowest human lives.

The ants belong to the great group called Hymenoptera — insects with membranelike wings, including the gall flies, bees, and wasps.

Ants are found everywhere. Long lines are seen marching along, some coming, some going, in countless multitudes. Yet drop a strange ant into this highway and it is at once discovered and in danger. If water is poured into a nest of ants, the inhabitants come rushing out. Some come to fight, and others bear in their mouths the young (Fig. 244), countless thousands, to a place of safety.

The ant is a trim, vigorous individual, fleet of foot, tireless, never weary, brave, industrious, a type of the worker. The head is large. The eyes are compound, with three single eyes. The antennæ are long, slender organs by which ants appear to recognize friends or foes, and possibly talk with them in some way. Certainly when two ants meet, a very strange interchange of courtesies with the antennæ is performed. The males and females are winged, and there is a third kind without wings, called workers.

Ants live in vast communities of from one hundred thousand to five hundred thousand or more. They excavate the soil and gravel, descend into the ground, and

FIG. 244. — Ants removing their young to a place of safety.

tunnel it in every direction (Fig. 245). In certain places they store food, in others eggs. The affairs of their vast underground city are carried on with a marvelous method. Although the ants have wings, these are soon cast away. At certain times the winged males and females swarm out of the nest and fly away, forming other communities. The males soon die; the females rid themselves of their

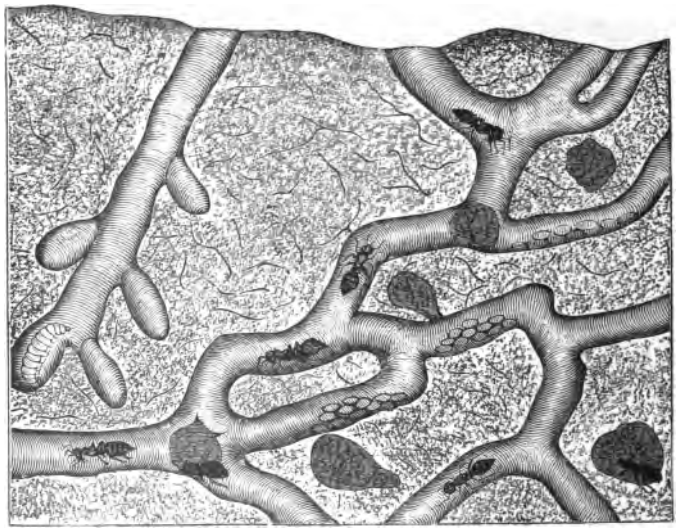


FIG. 245. — Tunnels of ants.

wings, and thereafter remain in their new nests. The entire work of the community falls upon the so-called workers. They make the nest, repair it, do the fighting when necessary, move the immature young or eggs, shut up the nest at night, and open it in the morning. The eggs are minute, and as soon as laid are taken by the workers, or nurses, as they are also called, and carried to

favorable places, where they are carefully watched. They are shifted about and occasionally for some reason brought above ground. The larvæ, when they hatch (Fig. 246), appear as little worms, or grubs, which would starve if they were not constantly fed by the nurses. If it is too cold, these babies are taken up into the sunshine, or placed in some hall near the surface where the sun's rays can reach them. Finally they change to the pupa stage and are covered by a web. They are still cared for with the greatest solicitude by the nurses, which stand by when they finally hatch out and aid them in their entrance into the world. Nurses in every sense of the word, their care at this time is one of the most remarkable exhibitions of human traits in a lower animal known. Many other human traits find their prototype among these minute animals. They care for the young, the sick, and the wounded; they go to war, capture their foes, make slaves of them, and force them to work. They keep certain insects for the pleasant odor they afford and others for the secretions they emit, the latter action resembling keeping and milking cows. Ants build remarkable houses arranged in rooms for various purposes; they plant gardens to raise certain crops; they introduce plants that will provide certain food; they retard the growth of seeds in their granaries; build vast underground or covered roads to escape the heat; they

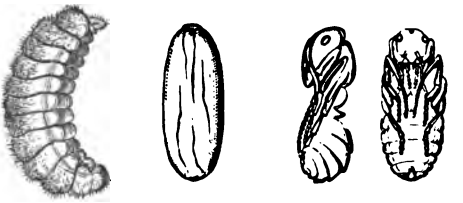


FIG. 246. — Egg and larvæ of the ant.

make bridges to cross streams; and in numerous other ways they demonstrate their remarkable intelligence.

The extent of the homes of ants is astonishing when we bear in mind the size of the insect. Some often extend many feet underground, and their tunnels have been traced beneath the broad Paraiba River of South America.

Many different species of ants are known, all interesting for their singular ways of living. The foraging or slave-

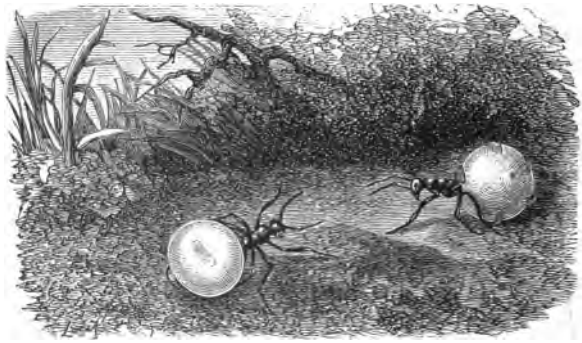


FIG. 247. — Honey ants.

making ants of Africa go to war against other ants. Such foraging trips are carried on with remarkable discipline, and the warriors may be seen returning, a triumphant army, bearing the eggs and larvæ of the enemy, which they nurse and bring up as slaves. These slave makers are large and powerful Ecitons, the dominant race of the ants.

Among the slave-making ants the owners often become so dependent upon the slaves that they are almost helpless, and would starve were it not for these dependents. The

so-called honey ants of Texas exhibit some remarkable traits in the manner of their lives (Fig. 247). These ants, which I have observed in the Garden of the Gods, Colorado, select certain individuals as storehouses and supply them with honey until the abdomen is expanded to many times its size, resembling a bottle. The ants when filled are placed in a compartment made for the purpose, and there hung to the wall, animated honey jars, which are taken down and made to give up their sweets as occasion demands. These honey balls are considered a delicacy in Mexico, and are served as dessert.

Among the ants, those of Texas known as the agricultural ants are remarkable for their intelligence. They are farmers, laying out places which they cultivate with a certain plant, which is especially to their taste, just as farmers plant corn.

XXIX. THE BEES AND WASPS

In almost every flower bed in the garden we shall find the bees, examples of tireless energy, storing up honey for their young in such vast quantities that the surplus forms a valuable food supply for man as well. The nests of bees are systematically robbed of their stores, and for this purpose the insects are supplied with artificial nests or hives, in which they deposit their honey, entirely for the benefit of mankind. Here we see a singular limitation placed upon intelligence. The intelligence of bees is wonderful and amazing. Many of their acts and works suggest those of human beings, yet when the time comes for thinking after the fashion of men, the bees are lacking. They go on storing honey in artificial hives without being able to bridge the mental chasm and perceive that they are being robbed and made to work as virtual slaves. Hence we assume that the intelligence of bees is not on the same plane as that of human beings. They appear to be acting upon a strong instinct which impels them to perform acts which seem intelligent.

FIG. 248. — The head of a bee.

The head of the bee bears two remarkable compound eyes, with three simple ones between them.

The antennæ are short. The mouth parts (Fig. 248) are complicated, and adapted for sucking up the honey or sweets of flowers or the juices of fruits. In California, the bees eat fruit as well as honey, and even flesh or meat, in very dry seasons, when flowers are scarce. The abdomen of the bee (Fig. 249) is supplied with a sawlike stinger or dart (Fig. 250) which inflicts a painful and poisonous wound. In general appearance the ordinary honeybee resembles an ant with wings; but the bee is hairy, it has a sting, and the legs of the worker are provided with "honey baskets," which carry pollen.

FIG. 249. — Bees: *a*, queen; *b*, drone; *c*, worker.


FIG. 250. — Sting of a bee.

Bees are of several kinds, queens, workers, and drones, there being a division of labor. The queen is the largest, the drone is the smallest, and it has no sting. The history of the bee and its development is one of the most wonderful chapters in the whole story of animal life. Glancing at the interior of a hive we see that the bees have constructed a series of hexagonal cells. To learn how they have accomplished this, we may follow

a bee in its flight. This may be one or two miles from the hive, yet so perfect is the knowledge of the bee of direction, that it is rarely lost. Reaching a flower it sucks out the honey, which it swallows. It then takes pollen, the dust from the stamen of the flowers, and stows it away in little baskets attached to the legs. It also takes a waxlike substance called propolis from buds of various trees, which it packs with the pollen in the baskets. Arriving at the nest, the bee, with countless others, engages in the construction of the cells, which are of various sizes. The material for building up the cells is wax, which is secreted by the bees, appearing in little flakes under the abdomen, from which it is taken by the legs of the bee. This is the material from which the comb is made, while the propolis is employed as a cement to attach the cells together, and for various minor purposes. Think of thousands of workers bringing in this material, working in the dark, yet never making a mistake. The bee finally ejects the honey which it has swallowed, placing it in certain cells, where it is sealed up and remains until it is needed as food. The pollen is also placed in cells.

A single community of bees may consist of two hundred thousand individuals. In the hive there is a single queen, which often lays from fifteen hundred to two thousand eggs a day, and if we could follow her, we should find that she lays the eggs in different cells, and in cells of different sizes. In the first are eggs which develop into workers, and in the second are larger eggs which will produce males, called drones. The little eggs soon hatch into white grubs which are carefully fed by the workers with digested honey

and pollen. Finally the young larvæ almost fill the cells and then stop eating. The workers cover them in, and each spins for itself a silken cocoon, in which it remains until it breaks out in the form of a perfect bee.

The workers build certain large cells on the side of the comb, which are called queen cells, and the larvæ which appear in them are fed with some peculiar food which produces queens. The workers watch each of these cells with great care, gnawing the wax away on top so that they can observe the progress of development. Finally a small hole is made, through which the proboscis of the young queen protrudes, and in this way it is fed for several days, during which it utters a low, piping noise. The queens attack each other on sight, and previous to the appearance of a young queen the old one, with thousands of followers, makes her escape, or swarms. Then the workers liberate a young queen, and if there are others, there are repeated swarms, each queen leaving with a multitude of followers, till the hive has but one queen. There are in the community now a number of drones, and as they appear to be an expensive and worthless burden to carry during the winter, the workers attack and kill them, throwing them out of the hive.

FIG. 251. — Carpenter bee.

Among the many kinds of bees the carpenters (Fig.

251) are famous, boring tunnels into solid wood for the reception of their young; half an inch a day being accomplished by these little carpenters. The bumblebee, one of the largest, forms its nest in the ground (Fig. 252).

FIG. 252. — Bumblebee and nest.

The wasps (Fig. 253) live in societies of males, females, and workers. The paperlike nests are familiar objects in the woods, resembling great bags of paper which when opened are seen to be filled with cells. Many nests are of beautiful shapes, resembling candelabra, while the cells of the common mud dauber (Fig. 254) call to mind the adobe houses of the Mexicans and Indians of the Southwest. The mud cells of a South American wasp resemble bottles (Fig. 255). Many of the large wasps are fierce and vindictive, and nearly all resent an attack upon their homes.

FIG. 253. — Wasp and young.

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